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THE MAKING OF THE WORLD

BY

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TRANSLATED BY ERNEST UNTERMAN

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LIST OF ILLUSTRATIONS

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1. Corona of the Sun during a Total Eclipse
2. The Nebula in Orion, after a drawing made at the Washington, D. C., Observatory.
3. Spiral Nebula in Canes Venatici. Photographic plate of Yerkes observatory.
4. Nebula in Andromeda. Photographic plate of Yerkes observatory.
5. Granulation of the Sun's Surface. Photographic plate of Meudon (France) observatory.
6. Star Cluster in the Centaur.
7. Milky Way in 6 Anseris. Photographic plate by Professor Wolf of Heidelberg.
8. America Nebula. Photographic plate by Professor Wolf of Heidelberg.
9. Sunspots, after the photographic sun atlas of the Meudon observatory.
10. Protuberances at the circumference of the sun. The sun is eclipsed by the moon.
11. Geyser in Yellowstone Park, Rocky Mountains.
12. A Crease in the Rocks on Axen Road, Switzerland.
13. A Cambrian Trilobite.
14. Silurian Crawfish, after Fraas.
15. A Devonian Fish with Armored Shell, after Zittel, Palæozoology.
16. Landscape from the Carboniferous Period.
17. Ichthyosaurus from the English Lias, after Owen.
18. Skeleton of Plesiosaurus from the English Lias, after Fraas.
19. Ceratosaurus, a giant Lizard from the Jura. Restored by Gleeson in the Smithsonian Reports.
20. Pterodactylus from the Solnhofen Slate, after H. von Meyer.
21. Archæopteryx from Solnhofen, now at the Berlin Museum, after Zittel, Palæozoology.
22. Petrified Leaves, found in Spitzbergen, after a photographic plate by the author.
23. Triceratops, a Pachyderm of the Tertiary Period, after a model by Ch. R. Knight in Washington Museum.
24. Mastodon (restored) from the time of the Diluvium, after Smithsonian Reports.

THE MAKING OF THE WORLD

"Spring will surely come again." Every human heart feels it in the dark days of every winter. Day and night, summer and winter, cannot cease to follow one another. There must be an eternal succession of birth, death, and ever new resurrection. And when the young green and flowers come in the new spring, then millions of beings, as though produced by magic, appear from the dark soil, the air, and the water. It seems as though everything would come to life once more. The tiny seed compels the dead earth all around it to unite with it and to share its germination, flowering, and generation of thousands of seeds out of one. Millions and millions of miraculously organized living beings rise every spring, after the winter had strangled other millions with his cold fists.

Will it really be always like that? In a former volume of this library I have shown that worlds come to an end, that our world likewise will cease to have day and night, winter and summer. But

THE MAKING OF THE WORLD

just as for innumerable of the minutest living beings, whose existence extends only over a few hours or minutes, a single daily revolution of this globe is the equivalent of an entire period of world-creation, bounded on either side apparently by eternal night and immobility, so it is permissible for us to assume that the beginning and end of this world, as we know it, are but the boundaries of one day of a greater cycle, of which we microscopic animals on this globe cannot know anything, and that, therefore, day and night, winter and summer, in a wider meaning, will not cease for all that, if we rise to higher stages of evolution in the universe.

The beginning of a world is but like a new spring, which reaches down into the matter of defunct world-systems with new creative energy, which makes worlds germinate and blossom, just in the same way that we observe with rapture all around us in our beautiful terrestrial nature.

The question is now: Where shall we begin our study in trying to witness the origin of some world with our mental vision? Our terrestrial spring is an immense world creation. Just realize that every molecule joining its mates in every rising germ is a world-system of atoms, more complicated in its structure and movements than

THE MAKING OF THE WORLD

our entire solar system. Everything builds itself, compelled by invisible forces, from the inanimate simple elements of the soil and forms wonderful organisms. These world creations of nature are full of the deepest mysteries.

But we generally mean by the term world that far cruder composition of matter which constitutes our earth, the solar system, and finally that largest aggregation of worlds known to us, which we shall see later at closer range as the Milky Way. How did these worlds come into existence? That is the question which we shall try to answer in this volume.

A thing arises — out of what? It cannot come out of nothing. We must assume that the substance of the world is present from eternity. Only let us imagine that it was in a state of complete chaos, without any organization, so that each particle of matter was not in touch with its environment and moved independently of all others in space. This would be a picture of the lowest stage of world evolution which we can imagine, a stage touching the last phase of that other half of a world cycle which ends in dissolution. A mighty collision of two extinct worlds may, at a certain time, have disrupted all organizations of matter, dissolving even the atomic sys-

THE MAKING OF THE WORLD

tems of the chemists into their ultimate primordial atoms. The sudden flaring up of a new star in the constellation of Perseus, which we observed in February, 1901, would be an illustration of such an event. Two or more dark world bodies had there met with a speed of 1000 kilometers per second, and a resplendent nebular substance emanated from the center of the collision, spreading through space in a spiral with the velocity of light. Only the mysterious processes connected with radium offer an explanation for that phenomenon in the farthest recesses of the heavens, where in the course of a few months a territory exceeding that of our solar system 150 times had been refilled with matter of the most infinitesimal structure. Radium also sends out every minute particles of matter with the velocity of light, the so-called electrons, which scatter in space without any mutual cohesion. And if radium were present in sufficient quantities, these particles would form just such a shining nebula as we observed around that new star.

We may at least assume then, that the primordial atoms, or electrons, which filled the space around that star in an inconceivably diffuse condition, are actually the simplest stones which have built up, not only the world of chemical atoms

THE MAKING OF THE WORLD

and molecules, but also that of the celestial bodies. They represent that lowest stage which is the starting point of our discussion.

We take it for granted that that world, which was thus dissolved into its primordial state, had seen better days before its end came. How can it be that the same natural forces, which led it slowly or suddenly toward its destruction, begin from that moment to lift the same matter into new life? How can the trend of world evolution be so completely reversed? The phenomena of terrestrial life, though vastly different in their external aspects from those of world processes, give a satisfactory reply to this question. Our bodies, after passing the climax of their development, move gradually toward their decline and dissolution, the same as all things in the universe. By themselves, by their own unaided powers, they could not propagate their kind. They would all irresistibly decline, were it not for a compelling desire which urges two of different sex to mate. At the moment of their union, different parts of these two bodies begin to change their course of development in an ascending direction. A new organism germinates and grows within another, which had completed its growing stage. It is universal love which creates the world of life; but

THE MAKING OF THE WORLD

the creative forces of that love are active also in the so-called dead matter of inorganic nature.

Millions of world bodies hasten through space, apparently without any definite goal. We see them going in all directions in the heavens, so far as they become visible to us at all in their capacity of suns. Other millions have no doubt become extinct long ago, but still they may pursue their course through the void and dark of space, apparently without any rule or law, without any destiny. They have not joined any known group of worlds, so far as we can tell, although we must assume that they belong to the most stupendous of all systems, the Milky Way. They could never generate out of themselves a new impulse which would lead them towards a new rise. Driven by vague feelings they are compelled to look for their mates in the recesses of the universe. And if two well mated world bodies meet and mutually transfuse one another in the wild longing for a new life, a mighty heat permeates their interiors, and a new world-being, composed of myriads of world-germs, which are hurled in all directions by the old bodies, fertilizes the void around it once more. A new star blazes forth.

It is but rarely that such events take place in the heavens. And only the very greatest will be-

THE MAKING OF THE WORLD

come visible in our field of observation. The two most imposing phenomena of this kind were witnessed in 1572 and 1901. The first of these was the Tychonic star, the other the previously mentioned star in Perseus. But since we have begun to keep a close account of celestial occurrences by means of photographic plates, we find more and more frequently among the millions of stars one which has not been registered by older plates, which must, therefore, have been born recently. It is worthy of note that most of the new stars appear precisely in those regions of space where the stars are most thickly crowded. Here they can find one another most easily for the stupendous act of world generation. This is no more strange than it is that the greatest number of children are born in the most thickly populated districts.

A luminous nebula was observed not only around the new speck of light in Perseus, but also around the new star discovered in the constellation of Auriga. But only in the case of the former was it possible to ascertain the immense velocity of its expansion. It was this velocity which suggested the thought that the expelled substance might be radium, or rather its emanation. I cannot refrain at this point from repeat-

THE MAKING OF THE WORLD

ing a thought which I expressed once before in another place. It is well known that radium is one of the heaviest substances which we handle. For this reason, apart from others, it is very probable that the earth and other celestial bodies contain large quantities of this wonderful substance. It may be that it is not formed in the interior of these bodies until after millions of years of such pressure as exists there. Now, when two world bodies collide and shatter one another, it is as though a pod of some fruit filled with seeds bursts open in spring, after having lasted through the long winter. It scatters its seeds all about and new life will sprout out of them.

Such nebular formations as those surrounding those new stars exist in large numbers in the heavens. They do not seem to vary, so far as we can tell. But we must remember that we are separated from them by immeasurably great distances, so that movements which take place with the immense velocity of 300,000 kilometers per second, as they do in the case of the nebula around the new star in Perseus, appear to us so small, that the path described by the light in months of time makes only a few millimeters on the magnified photograms. Therefore the mat-

THE MAKING OF THE WORLD

ter in those permanent nebulae may be whirled about with a relatively great velocity of hundreds of kilometers, and yet we may not be able to perceive this in the short time, in which we have securely fixed the impression of those formations on a sensitive plate. But this impression is sufficient in many cases to prove that they owe their existence and form to catastrophes similar to those which our eyes witnessed, so to say, in the flaring up of those new stars. The largest formation of this kind, which we know in the heavens, is the nebula in Orion, an illustration of which is given here.² It is especially interesting in view of the preceding remarks. We observe that the luminant mass has been wildly agitated, and yet there is a certain order, which plainly betrays signs of a former catastrophe, by which this distribution of the matter was caused. From the top, a dark space cuts into the nebular mass, which is sharply defined by it at that end. In front of this dark space, which has been named the Lion's Mouth, the matter is particularly concentrated in the center of the nebula, as though it had been compressed by some invading body. We see indeed at this very point a cluster of small stars,

² Figures in text refer to cuts, with corresponding numbers in appendix.

THE MAKING OF THE WORLD

which may very likely have been the intruders. The remainder of the matter is grouped around the Lion's Mouth, just as if it were radiating from there into space. Let us suppose for a moment that we have blown a cloud of tobacco smoke into the air, and then, after the smoke has somewhat settled, let a short puff of air act upon a portion of this cloud. A gap like the Lion's Mouth would thus be formed, and the remainder of the mass would at the same time be thrown into a whirling motion. Now, photography has actually demonstrated that a very dim spiral of a nebular streak emanates from the original nebula in Orion, surrounding in a gigantic circle the entire constellation of Orion. It is hardly possible to imagine that anything but an actual shock could have started this whirling motion.

Quite a number of such spiral formations, many of them showing the spiral outline still more clearly, are to be found in the heavens, particularly since the photographic plate penetrates ever more deeply into their mysteries and discovers, by means of many hours of exposure to the light, more details of those dimly shining clouds, than the giant telescopes could ever directly show to the eye.

The most famous of those spiral nebulae is that

THE MAKING OF THE WORLD

in the *Canes Venatici*, shown in the accompanying illustration after a photogram of the Yerkes observatory near Chicago.³ We see at the end of the spiral a nebular ball, whose intrusion may be assumed to have been once upon a time the cause of the whirling motion.

Of course, we do not see all these objects just in the plane of their greatest extension, but often only in a foreshortened form. For instance, the great nebula of *Andromeda*, shown in another illustration, whose spiral nature was discovered only after being photographed, appears as a flat lens, which is seen from our standpoint in the direction of its edges, and we note in a foreshortened perspective, that several turns of the nebular mass are winding around one another. In this case, a ball of nebula floats likewise a little outside of the turns.⁴

In view of all these evidences, we can hardly doubt that the first impulse for that rotating motion of world-bodies, which we see later uniting into solar systems, was given by a collision of two world-bodies, or two masses of nebulae, or aggregations of matter in various stages of development.

In the case of the nebula around the new star in *Perseus*, the movement of the radiating bunches

THE MAKING OF THE WORLD

of light showed also a spiral nature. Evidently it represents the embryo of a world body, whose very first impregnation we witnessed. What a pity that we are so short-lived and cannot observe the development of this new world-being any further! For it will probably take hundreds of thousands of years, before new stages of its growth will become noticeable.

But while we cannot watch this in the case of some one individual world-body, we can follow stellar development in a whole series of them, which are now in the heavens, by arranging them according to stages of development. The analogy has been pointed out several times, that in the case of the development of the chicken from the egg to the adult stage we do not necessarily have to study one and the same individual in its different metamorphoses, but may just as well study the various generations living simultaneously in the same yard.

Now, we find indeed in the heavens all the stages of development from that primitive, minute dissemination of matter, which we saw in the first stages of the nebula around the new star in *Pegaseus*, to the perfect systems of stars and suns. We shall let them pass in review one by one, in such a way that we may recognize the necessity

THE MAKING OF THE WORLD

y of their development along this road out of the
e forces and conditions of nature known to us.

a To this end we must return once more to that
e very first stage of world-creation, the classic illus-
- tration of which is furnished by the repeatedly
f cited *Nova Persei*. We shall, in so doing, also
s revert to our previous assumption that matter
resumed in that region its very primitive condi-
f tion, that of the arch-atoms, or *electrons*. For
v this gives us an opportunity to review with our
,, mind's eye the making of a world from its very
1 lowest beginnings. In reality, however, many of
- the declining worlds may not have completely re-
1 verted to this most primitive condition, before
1 they received a new impulse toward generation.

Now, whence do we get the forces of nature
which make for a new arrangement of the cha-
otic mass of freely circling atoms and lead them
gradually to those wonderful organizations which
build up our blossoming world? After the end
of a world, such as we have described, we can
avail ourselves only of those minutest building
stones, the arch-atoms, which we see speeding
through space in a straight line with an equal and
extraordinary velocity. It is the problem of sci-
ence to explain this stupendous structure by the
simplest qualities of the primordial atoms. How

THE MAKING OF THE WORLD

far we still are from such an explanation! But this atomic world from which we must proceed to that of the celestial bodies, if we would thoroughly understand their origin and organization, is precisely the one in which things begin to clarify of late. It becomes ever more evident that the same general order which holds the immense world-bodies together extends also to this finest arrangement of matter, that we may understand the world of atoms by the world of celestial bodies, and vice versa, that we may study the way in which suns turn back into atoms of the universe. By analyzing the structure of atoms, we learn to understand also that of the world-bodies. Let us, therefore, devote just a short while to the study of the atomic organization as seen by modern science.

It has been found that the bodies called atoms by the chemist and molecules by the physicist represent very complicated systems of worlds, minute though they seem to us. There was a time when chemical atoms were regarded as indivisible. Hence they received their name. By means of the experimental aids of our present time, we cannot even now dissect the chemical atoms into smaller particles. But the proportions of the atomic weights, which have been very accurately

THE MAKING OF THE WORLD

determined, clearly indicate a systematic arrangement of their elements. The atomic weights increase by gradations of integral numbers. This led to the idea that atoms are built up from arch-atoms in such a way that a definite number of these combined to form an atom of a certain element. One might have assumed, for instance, that one atom of helium is built up of four atoms of hydrogen, because the former weighs exactly four times as much as the latter. In reality, the thing is evidently not quite so simple. Or, one might think that one atom of sulphur consists of two atoms of oxygen, for sulphur is exactly twice as heavy as oxygen. Similar proportions are found in the atomic weights of all other chemical elements, and it is a fact that all their chemical and physical qualities depend on these atomic weights. Solely the atomic weight and the arrangement of the atoms determines all qualities of matter. An atom twice as heavy as another atom is also twice as inert in its chemical reactions, provided its arrangement is the same. In short, it becomes ever plainer that we shall some day explain all physical and chemical phenomena, that is to say in the last analysis, the entire world closely surrounding us, by a conglom-

THE MAKING OF THE WORLD

eration of arch-atoms into gradually increasing and differentiated groups.

In that case, then, we could look upon the world of atoms with all its qualities as having arisen from a great variety of differently arranged arch-atoms. It would not be hard to understand how this might have taken place. For we have seen that these minutest particles of matter whirl wildly about after the end of some world. Under such circumstances it seems natural that two of them should meet here and there and stay closely, or more or less so, together. This builds out of the primordial matter a bi-atomic body with different qualities. Other bodies of similar structure may then combine with them, or unite with them into a group, indivisible for us, but nevertheless composed of four arch-atoms, and so forth up to the heaviest atoms known to us. Now the lightest atom of chemistry, that of hydrogen, consists on this assumption of at least 2,000 of those arch-atoms, and the heaviest atom, that of radium (which, according to Runge and Precht, is 245 times heavier than hydrogen) would consist of not less than half a million of individual arch-atoms, and these would not be closely packed like the bricks in a building, but circling around a common center with rela-

THE MAKING OF THE WORLD

tively large intervals between them. We draw this conclusion from the behavior of these atoms in the molecules, which consist of groups of atoms which we can separate. In the molecules, we can study by experiment the manner of arrangement and qualities of atoms. A molecule of this kind presents to us the spectacle of a very complex world-system on a small scale. It may contain millions of individual world-bodies. The atoms may be likened to the planets with their systems of moons. But none of the planets of our sun has more than eight moons, or at best nine, as may be the case with Saturn, while an atomic planet may be composed of thousands of individual bodies, and thousands of such composite atoms may be swinging through one molecule.

In these minute spaces, eternally invisible for us, the essential processes of the universe take place. Whatever we may notice of them is but a magnified reproduction of events passing on a lower level, and even this reproduction is frequently obscured for our perceptions on account of the peculiarity of our sense organs, which apprehend a whole series of processes as though it were one single act and thus lose the peculiar characteristics of the individual processes of such a composite perception. For instance, we hear a

THE MAKING OF THE WORLD

certain sound as though it were one thing, while it really consists of a large number of individual vibrations.

An understanding of the atomic world would require in the last analysis an explanation of all natural forces active in it, such as the *gravitation* which holds the atoms together and also guides the individual bodies in the atoms and molecules around a common center like the celestial bodies in the greater cosmos; the *electricity* which may some day serve to explain also all chemical processes; the phenomena of *heat* which regulate the velocities and circumferences of the orbits in those molecular world systems according to laws explained by the modern theory of heat; and all other phenomena, for instance that of the uniform velocity and rectilinear movement of the arch-atoms. So far as this can be done in our time, I have tried to present the matter in a larger work entitled *The Forces of Nature*. For instance, I have endeavored to illustrate in this larger work how the attraction between two large bodies might be explained through the pushing power of very minute masses of particles moving in a straight line. If the so-called world-ether consists of such arch-atoms, which speed through space with the velocity of light, then the collisions

THE MAKING OF THE WORLD

of these arch-atoms, or ether-atoms, with the smallest world-bodies, the chemical atoms and physical molecules, would explain their apparent mutual attraction and all the laws of their movements, so that eventually it would not be necessary any longer to assume a special force of gravitation mysteriously radiating from matter.

We assumed that such simple arch-atoms were moving about in our primitive nebula, and we may, therefore, understand under the preceding conditions, how the atoms in process of formation and gradual agglomeration may seem to attract one another, and why they must form by means of combination those very minute world-systems with their swinging motions, under the influence of the unallied ether-atoms.

Thus we see this minute micro-cosmos arising, accessible to our theoretical research, if not to our sense organs. We see it assuming a more perfect organization to the extent that the small groups of individual bodies unite into larger systems proceeding on a common course in the turmoil of their historical stage.

But every individual, every atom, molecule, animated being, world-body, is limited in its growth to a definite extent. Every form in the universe has its time of rising childhood and adolescence,

THE MAKING OF THE WORLD

of full manhood, and of senility gradually disintegrating toward death. In recent times we have found indications that even the chemical atoms, which have so long been regarded as the most unalterable part of nature, are growing and declining, that they were not created for once and all by the first world-process, but are still altering, however slowly. Under these circumstances, an atom of a certain element may even nowadays transmute itself into an atom of some other element. And there is at least one case in which this has been observed. It is that of the very wonderful radium.

It seems that the radium atom has grown, under the tremendous pressure in the interior of the earth, to a size which interferes with its further development under normal conditions. Collisions of its rotating individual constituents seem to occur continually in the interior of this largest of atoms, for we may observe that an uninterrupted shower of those very minutest particles, called electrons, radiates from it. It also ejects larger particles, which, however, are still considerably smaller than the smallest chemical atom, and the velocities of these particles vary according to their sizes, some of them moving with the velocity of light. Radium represents a disinte-

THE MAKING OF THE WORLD

grating atomic world, scattering the products of its dissolution through its environing space in the same way which we observed in *Nova Persei*. And then it was seen that new and greater atoms were generated out of the products of this disintegration. Ramsay caught this *emanation* of radium in a glass tube. It is a resplendent gas of such extreme rareness that we cannot determine its atomic weight. But in a few days he witnessed the miracle of a gradual and steady transformation of this unknown gas into helium, the second in lightness of all known elements. Before our own eyes, as it were, atoms of an unknown minuteness had, under the conditions mentioned, combined into helium atoms. New atomic worlds had been generated.

But while an atom, an animated being, a world-body, individually, cannot grow beyond a certain size, they have on the other hand the opportunity of reorganizing into new and larger bodies. Groups of atoms become molecules, molecules become the visible objects around us, an animate body is built up of individual cells, and we may conceive of all the animate organisms of our globe as mutually interrelated parts of a uniform and growing organism. Finally aggregations of molecules become world-bodies, and swarms of

THE MAKING OF THE WORLD

suns become systems of Milky Ways. From the invisible micro-cosmos of the atomic world we rise once more into the celestial spaces of the macro-cosmos, which becomes as incomprehensible to our sense organs by its stupendous extension as the atomic world is through its minuteness. Now let us trace the development of the celestial bodies in this greater sphere.

In the combination of primitive substances during a new world-process, such as we took for our point of departure, the matter in the original mass of nebulae will not be equally distributed over the region of the process. In the nebula around *Nova Persei* we plainly noticed several distinct clusters of light. In the process of condensation unequally distributed centers are formed, and the entire mass gradually separates into distinct clusters of light, provided it remains luminous. We actually find such formations in the heavens, nebulae which on closer observation separate into a vast number of individual stars, although the spectroscope betrays without a doubt the gaseous nature of the whole mass. These are starry condensations of nebulae, not stars or suns which are liquid at least on their surface.

But such masses of nebulae must in time lose their luminosity. For the quality of effulgence,

THE MAKING OF THE WORLD

without a glowing state is solely found in matter in that condition in which it radiates small particles with the velocity of light, a condition which we observe in radium, or in certain electric phenomena, such as the cathode and Röntgen rays under certain conditions. But our mass of nebulae in process of world-generation must be of the temperature of space, that is to say a temperature near the absolute zero point, or minus 273 centigrade. To the extent that the number of atoms and other particles of matter increases in the process of condensation, they must lose their initial velocity. Every collision will result in a loss of motion. In the present case there would not be any actual loss, for we have assumed that the combining particles do not become closely packed and immovable, but begin at once to rotate in the atoms, molecules, or ultimately in the circling spheres which we watched in the process of becoming spiral nebulae. In other words, their rectilinear motion becomes a rotating one. The rectilinear motion could act in an outward direction, for instance by colliding with some other mass. But the circling motion is an internal one which cannot manifest itself outwardly except under peculiar circumstances. This second motion rather determines the internal qualities of

THE MAKING OF THE WORLD

matter. In the language of the physicist, live power, or *kinetic energy*, is converted into latent power, or *potential energy*.

With the decrease of the kinetic energy of our nebular mass it loses its luminosity, and our world-embryo disappears from sight, after having been the object of study for all inhabited spheres of the universe from the time when it first made its sudden entrance, just as did the new star in Perseus. But the process of condensation continues. Every mass left to its own devices in space condenses more and more. Under the influence of its own gravity it endeavors to concentrate itself into an ever smaller space, unless its rotating motion acts as a counterbalance to this gravity, as it does in the case of the planetary rotation around the sun. This process of condensation converts more and more kinetic energy into potential energy. The physicist demonstrates, however, that the phenomena of radiating heat, and later of light, begin to manifest themselves as soon as the rotation of the atoms in the molecule have acquired a certain speed. This is due to an influence of this rotation upon the ether of universal space. This ether, which according to our foregoing remarks consists of arch-atoms moving with uniform speed in a rectilinear direction,

THE MAKING OF THE WORLD

transfers the oscillations of the atoms through space to other bodies, and in this way we receive the impressions of heat and light.

The young world-body, or cluster of world-bodies, into which the nebular mass disintegrated, now grows gradually warmer to the extent that it becomes denser. It begins once more to glow and shine, but under very different physical conditions from those which caused the luminosity of the very rare nebular mass. Since the pressure must be greatest in the interior of the world-globe, because more matter is stratified there, it follows that the interior of world-bodies is considerably hotter than their surface. We know this to be so in the case of the earth.

Now, the process of condensation cannot proceed continually at the same rate. A body of some density cannot be as strongly compressed as a more loosely constituted one. Consequently the development of heat through the condensation of a certain world-body comes gradually to an end. The body at first radiates as much heat into space as it can reproduce out of itself. But by and by it cannot reproduce heat at this rate. It cools off. Of course, this will first affect its surface which is in direct touch with cold space. At a certain time the transition of the hitherto gaseous

THE MAKING OF THE WORLD

mass into a liquid state takes place. The principle of this transformation is the same as that by which the vapor of water rising from the lower and warmer strata of the air into the higher and cooler ones is transformed into clouds and condensed into rain. This rising vapor comes so close to cold space that it must condense into liquid water. The clouds consist as a matter of fact of liquid water which begins to fall in the form of a very fine spray. But in many cases the drops never reach the surface of the earth, for in their fall they soon pass through warmer strata of the air which resolve them into vapor. Thus it actually rains from every cloud, only the rain does not always reach us. If the earth had no solid shell on which water could be precipitated and collected, there would nevertheless be a continuous circulation of water. At a certain distance from the center of the earth clouds would form under the influence of the invading cold of space, and these clouds would bound the terrestrial gas ball at least for the outside spectator, although in reality it would be gradually losing itself in space. Rain would be continually falling from this hood of clouds. But at a certain altitude the rain-drops would always find a temperature which would dissolve them once more

THE MAKING OF THE WORLD

into vapor. This vapor, heated and lightened, would again rise to the boundary line where it would be condensed into clouds and drops, in order to start on a new cycle of transformations. Within definite boundaries, there would thus take place a continuous rising and falling of the water in its two aggregate forms. The cloudy surface of the globe would, therefore, present a fairly constant impression, although it would be continuously renewing itself, while above and below it a gaseous state would exist, the density of which would gradually decrease toward the outside.

Our sun is doubtless at present in this condition. However, those phenomena of condensation in his case are not due to watery vapors, but to metallic vapors, the temperatures of which must vary between 6,000 to 10,000 degrees centigrade. We see a veil of clouds drawn across the entire surface of the sun. They have for us a similarity with cirrus clouds, which float in the highest regions of our atmosphere. The accompanying cut depicts this so-called *granulation* of the sun's surface.⁵ In order to give the reader an idea of the size of these little clouds, I mention the fact that the entire diameter of the earth would occupy less than one centimeter of space in this cut. The stratum, in which these sun

THE MAKING OF THE WORLD

clouds float, is the so-called *photosphere* from which the most intense light emanates. The analysis of this light shows that it emanates overwhelmingly from metallic vapors. But there are also quite a number of other elements, familiar to us, in a gaseous condition. The spectroscope reveals to us furthermore that these gases are floating above a stratum of substances in the state of a fiery liquid, just as we assumed a while ago from purely physical considerations. Above this photosphere there is the *chromosphere*, which has received its name from its beautiful roseate color. It consists mainly of hydrogen and helium, the two lightest of the elements known to us. We see, therefore, that the gas ball of the sun extends beyond its luminous surface. Outside of the chromosphere, we observe at the time of solar eclipses the so-called *corona*, which loses itself gradually in space in the form of rays, as shown by the cut at the head of this description. The sun is, therefore, by no means a well-defined globe, but an aggregation of gases, which become condensed at a certain distance from the center, and the luminous products of this condensation form merely the semblance of a boundary line amid the surrounding gases.

Our world-body, then, has become a sun. But

THE MAKING OF THE WORLD

the primitive nebula will develop into more than one single sun. We have already seen that quite a number of points of condensation were formed, and every one of them becomes the germ of a new sun. Our vast expanse of world-mist becomes a star cluster, such as we see by the hundreds in the sky, and the spectroscope reveals the fact that the individual stars contained in them are actually suns, that is to say, world-bodies having liquid condensations under an atmosphere of glowing gases. We show such a star cluster in the accompanying cut.⁶ It is found in the constellation of the *Centaur*. It is one of the most beautiful of its kind. A more wonderful spectacle will be hard to find than that presented by such a cluster of stars when seen through a good telescope, a glittering multitude of suns relieved from the deep abyss of the heavens like a handful of diamonds. The star cluster in this cut shows a notable increase of the number of stars toward the center. We observe plainly that an originally uniform ball of mist was condensed gradually in its center to the extent that the condensation of the individual stars proceeded. Now we have before us a system of suns which are mutually related by common descent and probably revolve around the same common center.

THE MAKING OF THE WORLD

The greatest of these systems of suns is our *Milky Way*. The latest researches have suggested the probability that this system does not merely seem to encircle the entire heavens with its luminous ring, but actually occupies the entire universe accessible to our most powerful telescopes, so that all other bodies, the thousands of nebulae, star clusters, and individual suns, including our own sun with our earth, belong to this immense system of the *Milky Way*. We must occupy ourselves a little more closely with this greatest of all worlds, whose mode of generation will be easily intelligible to us after what has gone before.

It is well known that even comparatively small telescopes dissolve the general sheen of that immense celestial belt into countless small stars. But the abundance of stars becomes overpowering when but a small portion of the *Milky Way* is reproduced on a photographic plate by a long exposure. The accompanying photograph of a portion of the *Milky Way* in the constellation of *Anser* (the *Goose*) was taken by Wolf of Heidelberg after an exposure of about seven hours.⁷ This region contains no stars visible to the naked eye, and even the telescope would reveal only a few hundred of them. But who can count the

THE MAKING OF THE WORLD

stars discovered by the photographic plate in this one region of the heavens?

Even in this small portion we see that the stars are rather unevenly distributed, although they do not seem to be entirely without arrangement. In some places they seem to be arranged like pearls on a string, in other places dark channels with few stars are drawn through the swarming groups, just as though the matter had been displaced by some intruder. Again, in other places, lines of stars are drawn out like rays from some larger star, suggesting an internal connection of the entire group. Then again misty regions intervene which seem to form a new Milky Way in the picture of the Milky Way disclosed by the photographic plate. In those places, the abundance of stars becomes unfathomable even for the sensitive plate, although this plate reveals a great deal more than the most powerful telescope. The photography of the heavens has discovered a great many such misty regions in the Milky Way, among them the *America nebula*, so called on account of its startling likeness to that continent, as shown by another cut.⁸ It is not a mere play of accident that this nebula is surrounded by a zone poor in stars, which renders the nebula more conspicuous. We see plainly that the matter out of

THE MAKING OF THE WORLD

which this swarm of stars is generated, is trying to concentrate itself more and more. Out of the general uniformity, a world-body is beginning to emerge, although it still consists of thousands of individual suns, just as our body is built up of cells, each of which, aside from their common duties, has preserved a certain individuality. This *America nebula* represents an organism within an organism. And if we realize that each one of the thousands of stars in it is a sun like ours, and may have planets swinging around it like ours, and if we furthermore understand that this formation is but a very small portion of the immense organism of the Milky Way, we may be able to get a glimpse of the extent and sublimity of the universe, which everywhere follows the same laws of development and tends toward the same wonderful order.

Everywhere we see the Milky Way concentrating into such clouds of starry matter as in that small region, and the entire stupendous belt dissolves on closer inspection into similar formations. The general order of nature shows itself everywhere in its general outlines, but in personal matters it leaves room to stars and men for individual development in conformity with its great aims.

THE MAKING OF THE WORLD

Every one may notice on superficial observation that the Milky Way does not encircle the heavens in a uniform line. It is very broad in some places, and then it shines but dimly, while it is narrow in others, but filled with a countless multitude of stars. In another place it divides into two branches, which meet again later on. In the southern hemisphere, there is a large dark hole, called the *Coal Sack*, just where the line is brightest. On the other hand two large spots of light, the *Clouds of Magellan*, float far apart from the main line. Evidently they have separated from the great crowd.

Aside from these irregularities, we find that a wonderful arrangement of stars emanates from the Milky Way and spreads over the entire heavens. For if we count the stars, beginning at the Milky Way and proceeding at right angles from it toward the two poles equidistant from it, we find to our astonishment that the stars grow scarcer in a regular gradation. This is true of the dim stars as well as of the brightest. All of them are grouped in a general order around the Milky Way. It appears accordingly that the form of this immense mass of stars is that of a lens filled about uniformly with stars, although its center seems to be poorer in stars than its

THE MAKING OF THE WORLD

periphery. Our sun is located in its central region somewhat away from its actual center. However, later researches seem to indicate that the Milky Way is not actually a ring, but an immense spiral with several turns which is torn open at some places.

The greatest of all world-organisms known to us, which includes the entire visible universe, has therefore the same spiral form which we saw in process of formation in some of its parts after a collision with some other mass. If it is permitted to draw conclusions from equal causes as to equal effects, then it is probable that there is another similar universe outside of the one known to our observation, and the intruding mass must have come from that other universe beyond our range of vision. It may be that the *Clouds of Magellan* represent that intruder. If we could throw a glance at our universe from one of the poles of the Milky Way, then we should evidently find that it looks similar to the nebula in the *Canes Venatici*, which has likewise its Clouds of Magellan outside of its spirals. Thus the same arrangement of matter is found again and again, from the greatest to the smallest, from the system of the Milky Way to the atoms: Separate masses of matter, here suns, there atoms, with wide inter-

THE MAKING OF THE WORLD

vals of space, an approximately annular arrangement of the masses around a center, and a circling motion round this center. All the stars of our heavens show such movements. We have not fully grasped their course, because it will require thousands of years of observation. But the spiral arrangement of the Milky Way proves that its suns must describe such rotary movements.

We have now witnessed the genesis of the greatest of all world-organisms and understand the peculiar order of its arrangement. Seeing that its individual parts, the nebulae, the star clusters, and the individual suns themselves are all miniature copies of the great system to which they belong, we understand why their arrangement is the same in all essential points, and we realize the method of their generation. But before we return to our sun which we studied in its first process of condensation, it will be well for us to get an idea of the way in which a solar system like ours with planets circling in definite orbits must develop out of a nebular spiral condensing into balls of matter.

In order that such a solar system may arise, it is necessary that its largest mass should have condensed in its center and formed the nucleus of a sun as its predominating body. Around it cir-

THE MAKING OF THE WORLD

cle, as yet without definite order, the spirals which have already contracted into a large number of individual bodies of all sizes. The entire region which has thus been filled with matter has the form of a flat lens, with only a spiral protruding here and there. For we must take it for granted that the collision inaugurating the regeneration of this new universe does not let things proceed in very smooth harmony. We want to reconstruct the universe out of a chaos. But a chaos is utter disorder. It is impracticable to take our departure for the development of a theory of world-formation from uniformly distributed matter, which is supposed to fill space without any differentiation. For such an assumption would imply that all atoms are uniform, equidistant from one another, and move uniformly. This would be a condition of perfect order, perfect equilibrium, and there would be no impulse by which matter could be stirred out of it. An impulse from the outside would be indispensable in that case, in order to carry fresh tendencies of development into this equipoised mass. But in the case of our world embryo we assumed an unequal distribution of matter at the outset. This accounted for its primitive motion

THE MAKING OF THE WORLD

and the future arrangement of the growing system of worlds.

Its lenticular form is due to the collision, which sends out the spirals in the direction of the impulse. After this impulse all subsequent movements must follow the general law of gravitation. Some of the particles of matter will have received such a shock that they were hurled far outside of the sphere of gravitation of the general mass. These particles become meteorites and may occasionally penetrate into other solar systems. Whenever such bodies rush through our terrestrial atmosphere, their velocity indicates that they received the impulse for their motion outside of our solar system. All other masses assume elliptic orbits around the center of the general mass. Most of these orbits will be very elongated, like the orbits of the comets in our system. These long-tailed stars circle, or rather fall, with increasing velocity in the direction of the sun, rotate sharply around it in close proximity, and then wander off once more into the unknown regions of our system from which they had come. But in the first stages of the world-process there is as yet no sun. The entire inner region of the spiral nebula is filled by a conglomeration of variegated masses, all of them rotating around the

THE MAKING OF THE WORLD

same common center, but in almost circular orbits, otherwise they could not keep this center. The bodies with elongated orbits pass through this center and necessarily collide now and then with masses which deprive them more and more of their initial velocity, so that their orbits become less and less eccentric, approach a circle, and decrease in circumference. We can study this course of things in the case of some comets. They are "captured" by the large planets, especially by Jupiter, whenever they come too close, are forced into narrower orbits, and thus become periodically returning comets.

Such interference with the motion of bodies, in co-operation with the general laws of gravitation, arranges the orbits of all bodies or conglomerations of masses in the primitive nebulae in the form of rings around a center and clears the space between them more and more of matter. It is supposed that planets are formed out of such rings. Since the days of Laplace it was simply assumed that the substance of the rings gradually contracted around their densest part and became stratified into an individual body. Laplace himself never subjected his theory of creation to a close mathematical test, nor did he ever claim that it was anything more than a scientific hypothesis,

THE MAKING OF THE WORLD

which might very well be modified. In the meantime it has been found that a revision of this theory is indeed imperative. Quite recently an analytical thinker has discovered that bodies rotating in the same orbit around a common center have not the tendency to approach one another, but rather to arrange themselves in such a way that they avoid any collision, if possible. The unaltered condition of the rings of Saturn, which are composed of an innumerable mass of individual bodies, proves the practical correctness of this theoretical calculation. Of course conditions turn out differently when a small body in one of these rings approaches a very large one so closely that it is caught by the gravitational force of the greater body and follows it rather than the central sun. This is what happens in the case of meteorites and falling stars, which are caught by the earth. These small bodies must necessarily fall upon the larger one. We see once more, then, that the predominance of a large body in those rings is required, if it is to develop into a planet, just as we observed it in many spiral nebulae. But in that case we can dispense with the theory of annular formation and proceed immediately from a spiral nebula. The remaining mass of the spiral then develops into a ring. It

THE MAKING OF THE WORLD

seems that our earth is still floating in such a ring, which produces the *zodiacal light* by means of the reflection of the sun's light on the part of the minute particles that float with the earth around the sun. The belt of small planets between Mars and Jupiter is attributed to the fact that there was never any predominant condensation of matter in that region.

The same causes, which led to the formation of planets around our sun, are also active in grouping moons around these planets by the arrangement of larger masses which were available in their vicinity. Strictly speaking, the moons are independent planets, which, being the same distance from the sun as their ruling bodies, must move around it at the same speed. Their orbits are merely periodically influenced by the particular gravitation of their planets. The orbit of our moon around the sun is thereby transformed into a slightly undulating line. It does not form loops, as might be inferred from its twofold rotation.

In the same way, we may conceive of the rotation of the planets around their own axes as being due to the concentration of the masses which moved in the ring of each planet, in its sphere of gravitation, around the general center. The

THE MAKING OF THE WORLD

velocity of motion must have increased originally from the inside of the nebula toward its outside, inversely to what takes place in the case of the present planets, because the gravitation in the interior of a body filled with matter increases with the distance from its center, as it does in the interior of the terrestrial globe. The deeper we descend into it, the smaller becomes its gravitational force, and at the center it is zero, because at that point the attraction from the outside is the same on all sides. The external portions of a certain ring, then, move faster than its internal portions. During their concentration into a planet, the external portions of a ring, being farther away from the sun, would have a tendency to outrun the internal portions. In this way a rotary motion came about, so that the planets seem to be rolling along in their orbits.

In short, all movements found in our solar system may be explained out of the conditions described by us. And now we may return to the individual sun which we studied in its first stage of development. The concentrating bodies which later become planets also develop first into suns. But being of smaller volume and therefore developing and retaining less heat, they would cool faster than the central body, provided there is

THE MAKING OF THE WORLD

one, which is not always the case. The thousands of twin stars in the heavens show that one system may simultaneously have more than one sun. Some of these twin stars are differently colored. One of them may have a green light, the other a red one. What a wonderful play of colors there must be on the planets that revolve around such twin suns! We can scarcely imagine the beauties of their nature. Our system likewise witnessed such days. The great planet Jupiter must have been a second sun. Cooling off faster than the central body, Jupiter gradually passed into a state of red heat at a period when our sun probably was radiating still more blue light than it is today. For a careful examination of the present sunlight shows that it is assuming a slightly yellow tint. Jupiter still seems to radiate a little of its own heat, and beneath the clouds of its visible surface there seems to be a slightly glowing crust.

We had left our growing world-body, when it was a ball of gas and just forming a red hot and liquid surface under the influence of the penetrating cold of space, which condensed the denser substances into clouds and made them into rain. The red hot rain-drops were soon reconverted into vapor, because the inner strata of the gas ball

THE MAKING OF THE WORLD

had a higher temperature than the exterior ones, in which condensation took place. There was, then, a continuous circulation between the outer and inner strata, the same as in our atmosphere. In short, conditions of the "meteorological" sort in the outer strata must be much the same as on our earth even in solar bodies, in spite of their higher temperature, so far as general principles are concerned. For these bodies also revolve around their axis. For this reason, the upper strata of their atmosphere on the equator must fall behind those at the poles. This must produce regular trade winds and a general classification of meteorological zones. There must be an equilibration of the general currents of the air between the poles and the equator, and these currents must meet somewhere in an intermediate zone and form vortices, or cyclones, in which the condensations increase just as they do on earth, and by the same physical laws. For this reason we observe on the sun, in a certain intermediate zone, not on the equator or the poles, the generation of *sunspots*. They appear as whirling motions at the first glance, and when they are carried toward the outer margin by the rotation of the sun, we may clearly perceive that they are indentures in the atmosphere.⁹ It has also been

THE MAKING OF THE WORLD

discovered by direct observation that the sun-spots radiate only about half as much heat as the remainder of the sun's surface. This similarity of conditions with terrestrial ones goes so far that these solar cyclones are doubtlessly accompanied by electrical phenomena of a violence which surpasses our imagination. These electrical discharges are even communicated in a very perceptible manner to the earth across the 150 million kilometers that separate us from the sun, and effect tremendous fluctuations in our electro-magnetic conditions. When the solar cyclones increase in number, all magnetic needles in all parts of the earth become very restless. Magnetic currents run along under the surface of the earth and penetrate into the telegraph lines connected with the earth. The sun thus reaches across space into our apparatus and informs us by means of this wireless telegraphy on a gigantic scale of the titanic struggle of the elements in his youthful body. At the same time the highest strata of our atmosphere are illumined by the mysterious *aurora borealis*, which sends its rays from pole to pole in order to compensate the electric disturbances. These rays of the *aurora borealis* are very like the glowing discharges in the so-called Geisler, or cathode, tubes. Such dis-

THE MAKING OF THE WORLD

charges take place only in very rarified gases, in which lightning-like phenomena are no longer possible. In the extraordinary rarified air of the sun, in which those revolutions take place, only such glowing discharges can occur as cannot be easily observed on account of the intense radiation in their environment. But frequently we see mighty and flaming tongues of red shooting forth over the rim of the sun, the so-called *protuberances*, which expand with such extraordinary rapidity that of late the question has been raised whether it is really matter which is expelled at such moments, and whether these formations have not really existed all the time and have only become visible through electric discharges which spread with great rapidity in those clouds of hydrogen and helium.¹⁰ Quite recently it has been suggested that the sun may be darting forth from its spots those electrons which continuously emanate from Radium with the velocity of light. These electrons are supposed to cause abnormal electric conditions on the sun as well as on the earth.

After the gigantic struggle of the elements a temporary calm follows, for this struggle seeks to restore the equilibrium. The incessant work of condensation then proceeds more quietly. The

THE MAKING OF THE WORLD

products of condensation begin to form a red hot liquid shell at a somewhat lower level around the gas ball. This shell is constantly made and unmade, but after a certain time it is but rarely shattered from the inside, because the process then goes on more uniformly. However, the further condensation of the solar body increases its aggregate temperature, especially in its interior. At a certain moment it will have increased to such a degree that it cannot let the liquid shell remain intact. The liquid is pushed aside at its weakest places, where the general circulation of the solar mass offers the best opportunities for counteraction. Then a new period of sunspots begins. It is known that our sun has such periods of a greater disturbance of his atmosphere about once in eleven years, and in the interim his surface is unusually clear. We have now demonstrated the physical necessity of such pulsations. This phenomenon greatly resembles, in a physical way, those of geysers, which likewise have periods of sudden eruption in definite intervals, during which heat is gradually accumulated in them by way of the interior of the earth. We shall revert to this later.

To the extent that the cooling process continues, the sunspots will grow in number and

THE MAKING OF THE WORLD

will periodically darken our developing sun more and more. This stage of evolution is also represented by certain stars, the so-called *variable stars*, which have a long and somewhat irregular period. The sunspot period is likewise subject to fluctuations around a certain average. The most characteristic star of this class is *Mira* in the constellation of the *Whale*. This star is periodically one of the brightest, its light is midway between the first and second magnitude. Then it becomes gradually dimmer, until it disappears for the naked eye about seventy days after its maximum. It may be further observed through a telescope for three or four months more, during which its light varies between that of a star of the ninth or tenth magnitude, always growing dimmer, until it grows once more brighter, at a faster rate than it decreased. It reaches its next maximum about 333 days after the preceding one. It requires about 40 days, from the time it is seen by the naked eye, to reach its maximum, while it took 70 for its disappearance. It is this peculiarity of a faster increase than decrease which the wonderful little star shares with the sunspot period. However, these periods are observed only approximately, not strictly, and may vary as much as one month.

THE MAKING OF THE WORLD

Sometimes this star does not reach more than a light of the fifth magnitude at its maximum, so that it does not become visible to the naked eye, except under favorable conditions. The spectro-scope reveals the fact that at the time of the maximum of this star, and of others like it, a resplendent hydrogen rises out of the interior. This betrays the eruptive character of the phenomenon.

Little by little the liquid shell of our solar body becomes stronger and more resistant, so that it endures and is but rarely disrupted in isolated places, where gases escape from the interior. It might appear impossible at first sight that a liquid stratum should be able to rest permanently upon a gaseous one, as we assume. But it must be noted that entirely different conditions obtain in the dimensions of a world-body than in our laboratories. The pressure of the masses of such a body compresses the gases very strongly and yet keeps them in a gaseous state by means of high temperatures, so that they are heavier than the liquids which are condensed over them. And if there are really heavier products of condensation, they sink into the depth and are redissolved by the heat of the gaseous center. In this way a process of selection among the various

THE MAKING OF THE WORLD

substances gives stability to the liquid stratum.

Our solar-body, then, has acquired permanently a red hot liquid surface. We know that our earth was once in this stage, for wherever we penetrate far enough into its crust, we find primitive crystalline minerals, such as granite and gneiss, which form the backbone of most of the great mountain systems. These primitive rocks have in all essentials the same composition as the lava which the volcanoes vomit forth from the depths of the earth. Therefore the entire surface of the earth must have consisted of lava once upon a time. The interior of the earth, now as then, must still consist of gases, for the process of further condensation could not alter those internal conditions in any way. We also know that the interior of the earth is considerably heavier than its average surface. The specific weight of the entire mass of the earth is about equal to that of iron. But the rocks of the earth's crust are lighter than iron. We observe furthermore, that the temperature of the strata of the earth increases one degree with every 30 meters of depth. In this way we arrive at a relatively slight depth at temperatures, in which no substance known to us can exist in any other but a gaseous state. These experimental facts, then lead us by another way

THE MAKING OF THE WORLD

to the same conclusion as our theory of the making of the world, namely that the interiors of world-bodies must be in a gaseous condition.

By continued cooling, solid slag is formed on the liquid surface of our ball of gas, the same as in streams of lava. This slag, being a crystalline product, is generally lighter than the liquids in which it forms. It floats on them like ice on water. True, there are many substances, which are heavier, in the solid than in the liquid state. In that case they will sink and dissolve once more, just as we saw it in the case of the play of forces between the liquid shell and the gaseous interior. Under these conditions, the liquid stratum must remain heavier than the solid crust forming upon it. The floating flakes augment and are driven together by currents. They rub off their sharp edges against one another, cling together, and consolidate, forming in course of time large continents of slag. A world-body in this stage shows dark and light places, and since it revolves around itself it will alternately turn these places toward different directions of the universe. When seen at a great distance, in which it appears as a star without a diameter, it will change its light in periodical intervals, which will remain generally equal, or which will be sub-

THE MAKING OF THE WORLD

ject to slow alterations only to the extent that the dark regions of slag have not yet acquired a permanent position on the liquid surface, but are drifting about on slow currents. This leads us to a special class of variable stars, which correspond on the whole to the *Mira* type, but whose light varies more regularly and in shorter intervals. Some of these stars have also secondary minima of light, which seem to indicate that slag islands of different dimensions are distributed over the surface of the revolving star. Another phenomenon now visible in the heavens has thus been recognized by us as a link in the great chain of evidences in the development of the universe.

While the surface of the world-body is more and more incrustated, its original white heat is gradually tempered to red heat. The color of a liquid or solid body in a glowing state expresses immediately its temperature. Red heat begins at 525 degrees centigrade, a body glowing with a light cherry red, no matter what may be its substance, has a temperature between 800 and 1,000 degrees. A body glowing with a yellow light has about 1,200 degrees of heat, and white heat begins at 1,500 degrees. Now, we see in the heavens stars of all gradations of colors, from deep ruby red to bluish tints which indicate the highest

THE MAKING OF THE WORLD

degree of heat. The universe, then, contains world-bodies of all degrees of temperature. And it is very significant for our theories that there are more red stars among the variable ones than among the others. For those causes of variability, of which we spoke a while ago, can be generated only in the last stages of the cooling process of the glowing surface.

The body slowly acquires a solid crust which radiates but little light of its own. Above it hovers a dense atmosphere of smoke and gases, which are expelled by the slag surface, or which may break through it from the interior. Frequently a large region of slag will be burst open and flooded with glowing lava. A lake of liquid glowing minerals is formed, which becomes but gradually encrusted in the course of a long time. A world-body of this kind, seen at the proper distance, will impress us much in the same way as the planet Jupiter. We see only the outer strata of its atmosphere, the same as of the sun. Since Jupiter revolves around its axis very rapidly, the clouds separate very plainly into zones. In the seventies of the 16th century, a large red spot appeared in one of these zones. At first it betrayed its presence only by a faint glow, but soon it assumed a more intensive color, which

THE MAKING OF THE WORLD

faded very slowly. It has not quite disappeared yet. During the time of its existence it showed a motion of its own, of a varying velocity, on the surface of Jupiter. It fell very slowly behind the normal revolution of the planet. This phenomenon can be explained only by assuming that Jupiter is in the cooling stage previously described, and that the red spot was the visible reflection in the clouds of a lava lake of continental dimensions, which had burst through the surface in some way. (See also "The End of the World," pages 96 and 97). Owing to the rapid rotation of the planet, the lava lagged behind and flooded the shore opposite the direction of the rotation, while the incrustation could proceed more easily on the other shore. This explains the receding movement of the spot over the surface.

We still have one or two such lava lakes on our earth. One of them is in Hawaii, in the crater of Kilauea, and a smaller one is in my opinion in the Stromboli volcano, on one of the Liparian Islands north of Sicily. The lava lake of Kilauea is continually covering its surface with slags that cling close to one another, so that we see at night a brightly shining network of fine lines incessantly moving across its red glowing

THE MAKING OF THE WORLD

surface. However, these cakes of slag can never become consolidated, because every now and then a jet of liquid minerals, several meters high, spouts up through the slag and floods and dissolves everything. Many indications make it very probable that this lake represents one of the last remnants of the primitive liquid surface of our planet.

Just as we have seen it in the case of the gases and vapors of the atmosphere, so the fiery liquid surface of world-bodies must have its currents, which are due partly to the rotation of the body, partly to the circulation of matter caused by the equilibration of temperatures between the inner and outer strata. Here, as in other similar conditions, currents will be struggling with counter-currents, and in such regions the cakes of slag will be shoved against one another so violently that they will pile up to great heights. If the slag has assumed continental dimensions, gigantic ridges will be formed on its surface, *mountain chains*, which extend over a large part of the planet, as do, for instance, the Andes, which extend almost from the North-Pole to the South-Pole, and which consist, so far as their backbone is concerned, actually of that primitive mineral mass which built up the first solid shell

THE MAKING OF THE WORLD

of our earth. But if the Andes owe their origin to the piling up of cakes of slag through the interaction of great currents, then the position of the equator at the time of their formation must have been diametrically opposite to that of today. For such currents and counter-currents as we assumed here will only be found running parallel to the equator. We note this by the way, because we shall have to discuss later a number of facts, which can be explained only by a slow displacement of the terrestrial axis out of its original position.

If the mountains have really been formed by such piling up of cakes of slag, then the shell of our earth is by no means stronger, but rather weaker at such places than in the plains, for then the mountains do not signify an increase in solid matter. This has been corroborated by many observations. There must have been a time, when our planet drew over its surface just such a network of cakes, as we see in Lake Kilauea. This network became more and more solid, but it represented nevertheless lines of least endurance in the shell, through which the fiery liquid, the magma, could easily break. Then, too, at such places the cakes, although solidified, could still be slightly moved against one another, whenever

THE MAKING OF THE WORLD

the further upbuilding of the world-body, which we may now call the earth, made extensive dislocations on its surface necessary. We may still recognize such long lines of rupture in the surface of our earth, wherever "tectonic earthquakes" are most frequent and shake large tracts of land simultaneously by convulsive motions. One of these lines of rupture, for instance, runs nearly at right angles from the Andes past the Antilles, across the Atlantic ocean, and on beyond the Caucasus. The crust of the earth has been especially restless along this line of rupture since the recent catastrophe in Martinique. Our planet wants to take another step forward in its development along this line.

With the formation of a solid crust our planet enters into its *volcanic age*, in which it is to this day. Volcanic eruptions at first dominated the whole earth. Their effects were felt everywhere, but for this reason they were, perhaps, less violent, because the pressure could easily escape at any point. We shall trace the development of volcanic phenomena through the ages, before we consider any of the other influences which have given such varied expressions to the face of the earth.

We understand, after what has gone before,

THE MAKING OF THE WORLD

that the interior of the earth must continually exert its influence against the outer shell. The play of natural forces, which causes the sunspots to break out occasionally, goes on without interruption. The struggle between the heat, generated by the pressure of the masses, and the invading cold of space always continues. This cold grips the solid shell much more strongly than the fiery liquids and seeks to press it tighter. The shell of the earth then feels too tight. It bursts open and lets out the fiery magma. The cakes of solid matter sink deeper, for they are mainly held up by the resistance of the mountains. Thus cavities are formed between the mountains, the future beds of the oceans. On account of this sinking process, the cakes along the piled up chains of mountains become unsettled, and finally they slide off along the whole line. The other cakes are left standing and form a wall of mountains slanting steeply toward the cavity. Such a landslide took place, once upon a time, along the whole chain of Andes. But at that period the oceans had long filled their beds.

During the first period of the formation of this crust, when such breaks took place on a large scale, whole oceans of magma may have flooded the surrounding country, and if the ground under

THE MAKING OF THE WORLD

them consisted of more fire-proof material, the magma may have stood for a long time in such a bed. In this way large lakes of fiery liquid were formed and separated from the magma in the interior of the earth by solid rocks. After a while, the fiery lakes also became encrusted, as water lakes do with ice. By this process crystalline strata of a horizontal stratification and structure were formed. The primitive rocks reveal often in a startlingly marked degree the fact that they have been formed, like the "sediment strata" above them, by the deposition of material in oceans. According to the opinion of the Paris lunar scientists Loevy and Puiseux, the wide ocean plains of the moon have been formed in this way. For this satellite of the earth must have gone through a corresponding stage of evolution, and since the water and the work of disintegration never played a very marked role in the upbuilding of its surface, it has preserved the general characteristics peculiar to the process of incrustation and cooling, while the surface of the earth naturally altered its aspect considerably through subsequent influences, which we shall discuss later.

It is well known that the surface of the moon is completely covered with "craters." Their

THE MAKING OF THE WORLD

number is estimated at 100,000. It would seem then, that volcanic agencies played a far more powerful role on our satellite than any known to us on earth at present. For the extension of the individual lunar craters is considerably greater than that of our largest volcanoes. The lunar volcanoes generally have still other, special, peculiarities, which make it at least doubtful whether they are genuine volcanoes. If we recall for a moment our conception of the genesis of world-bodies out of colliding masses, which were arranged along a circle, we might imagine that the circular mountains of the moon were produced by the fall of smaller moons of the primitive circle. These moonlets broke through the solid shell of the moon and disappeared in the fiery liquid of its interior, which rendered them into a fiery liquid. The opening made in this way became naturally a sort of volcano and produced further volcanic phenomena in its vicinity, which may not be entirely extinct on our satellite to this day.

The fact that the earth has not preserved any such traces of ancient collisions with the individual masses of the ring of world-bodies, so far as its surface shows, is due to the very long time which this planet required for the formation of

THE MAKING OF THE WORLD

its solid shell. Meanwhile all great masses of the primitive ring were united with it, while many a meteorite, which still strikes our atmosphere and is exploded by it, belongs to the remainders of this primordial ring. The atmosphere of the earth in pristine ages was doubtless still denser than it is today, and consequently it protected the surface of this globe against the direct contact with cosmic masses, a thing which can never have been a fact to the same extent on the moon, because a smaller body always surrounds itself with a smaller atmosphere.

Now, the volcanic activity of the earth and kindred bodies had to undergo some changes with increasing age. The thickness of the solid crust was continually increasing. It offered an ever greater resistance. The volcanic eruptions became rarer, but more catastrophic. We can verify this statement by observing our present-day volcanoes, which have so much more violent eruptions the longer they have rested. The example of Mount Pelee on Martinique is still fresh in our memory. The catastrophe of Pompeii occurred when Mount Vesuvius was no longer known as an active volcano. For the present, however, no destructive eruption is expected from

THE MAKING OF THE WORLD

it, because it is having a succession of small eruptions.

We recognize from what has gone before that separate craters of volcanic action would be formed, corresponding to the separate lakes and seas of liquid fire. Nowadays there is probably not a single volcano of this globe connected with the fiery interior, or if there are any, they are very few. In this respect the example of the two volcanoes, *Mauna Loa* and *Kilauea* on Hawaii, is significant. The first has a height of 4,170 meters and is the largest active volcano of the earth. The lava is continually in a state of liquid fire in its mighty crater, and it is thrown up in mighty jets. The same takes place in the crater of *Kilauea*, 3,000 meters below that of *Mauna Loa* whose parasitic neighbor it might be considered. But there is nothing which the eruptions of these two volcanoes have in common. These two lava lakes cannot have the same reservoir in common, for instance, they cannot both lead into the fiery interior of the globe, because the difference of their levels cannot be explained on this assumption by the laws of hydraulics. It is not possible for any liquid to maintain itself at different levels in communicating tubes, such as these two craters would have to be. But perhaps

THE MAKING OF THE WORLD

one of them is still in communication with the magma, while the other may be connected with a separate reservoir of lava.

Geological investigations have revealed the fact that the volcanic activity of the earth suddenly increased appallingly after a period of relative rest about the middle of the Tertiary period. This is the period in which the Pacific clod was torn loose and the volcanoes of the Andes became active, which were then far more numerous and larger than now. But their present activity still betrays the after effects of that wild epoch of terrestrial evolution, which also gave rise to the Alps and molded the features of the earth into their present form.

The cause of this stupendous change of the entire surface of this globe can be found only in a mighty disturbance of its equilibrium. By this means the old and more or less conglomerated clods were partly rent asunder and piled one over another. Such a disturbance of the equilibrium could come only from the outside, through cosmic forces. Perhaps it was a smaller moon, one of the last greater masses of the cosmic ring, which fell upon the earth and changed the position of the equator.

It is universally known that the rotation of the

THE MAKING OF THE WORLD

earth around its axis has accumulated more matter at the equator than at the poles, so that this globe has the form of an ellipsoid. If the earth were an absolutely rigid body, which could no longer be molded in any way by the work of natural forces, then the present coincidence of the swelling around the geographical equator with the actual equator of the rotation would prove that the earth's axis did not alter its position since that primitive period in which the solid crust was formed. For this reason this ellipsoid form was for a long time regarded as the surest proof that the earth was once in a state of liquid fire. But nowadays it has been proved theoretically and practically that there is nothing absolutely rigid, that even the hardest rocks are amenable to plastic alterations under strong and continued pressure, so that barring a certain lapse of time between cause and effect the earth must always have that form which it would have, if it were a red hot liquid. Consequently, if the poles have wandered over the surface of the earth, the swelling at the equator must have changed its position accordingly. In other words, a mountain chain 20 kilometers in height and reaching all around the globe must be wandering over its surface. Of course, this is taking place very

THE MAKING OF THE WORLD

slowly, but we can well understand that this process must continue to shake the ancient clods and keep them in a condition of imperfect consolidation.

A very considerable dislocation of the earth's axis would naturally have been produced by the downfall of a moon upon our planet, even if the mass of the falling satellite was but small. We may get an idea of this occurrence by pushing a spinning top, which will strongly vacillate even after a slight push. Now, the peculiar conditions of the glacial age indicate strongly that the poles were displaced in that period by about 20 degrees. And this can be due only to cosmic influences. In short, there is much evidence for the belief that the earth experienced in the Tertiary period a catastrophe which almost amounted to the destruction by a collision. I have spoken at length of this event in another volume of this library. However, this catastrophe implied an essential advance in the development of our planet. It was especially the volcanic agencies which entered a new phase. We are still living in it, and we may still observe one of the after-effects of that catastrophe in a slight vacillation of the terrestrial axis.

Millions of years passed before the deeply agi-

THE MAKING OF THE WORLD

tated earth was somewhat pacified. Most of the volcanic openings created at that period have closed in the meantime. The present volcanic activity is but a weak survival of the original one. In many cases, the ancient fury of the fiery eruptions has dwindled down to hot springs and other beneficent phenomena. The thermal spring at Karlsbad, Bohemia, is the foremost of these springs. It may be regarded as a volcano of hot water in continual eruption. Formerly the Iron Mountains of Bohemia contained many active volcanoes.

Another one of the after-effects of the ancient catastrophe is the charming play of geysers, which illustrate a certain stage of volcanic development still better than the Karlsbad spring. It shows a stage of terrestrial development in which the fiery shell has become rigid, while water has assumed the role of the magma. The geysers arise on hot volcanic ground, sometimes in extinct craters.¹¹ The water of atmospheric precipitations penetrates into the hot interior of the earth and fills the craters. In those depths, the water can assume much higher temperatures than 100 degrees without boiling, on account of the pressure of the column of water above it. And at a higher level the cooling process keeps

THE MAKING OF THE WORLD

the temperature below the boiling point. For this reason the water begins to boil at a definite depth of the crater, overheated water being carried up to it continually from the interior. The water above the boiling level is then ejected. This makes room for the water below it, and permits it to boil in its turn. The play of boiling waters is thus continued until all the water has been ejected. Then it ceases suddenly and begins just as suddenly later, after the temperature has risen sufficiently at that definite level. This activity of the geysers has a certain physical similarity with the eruptions of the protuberances and spots from the interior of the sun, and also with genuine volcanic phenomena. Let us imagine for a moment that there will be a time when all oceans will be covered by a crust of ice several kilometers in thickness, in which there will be just such deep fissures and breaks as we now find in the solid crust of the earth. Then the water will be ejected from the interior of the earth by eruptions in certain places in the same way that the magma is now.

We have seen many details of the development of our world-picture in the course of this presentation. But still it seems void and dreary when compared with the wonderful variety of natural

THE MAKING OF THE WORLD

beauties which surround us today. Today the volcanic eruptions play but an insignificant role in the configuration of the surface of our planet. Most of the mountain chains have no longer any volcanoes, whether they be active or extinct.

We have already noted the manner in which the mountain ridges were formed by the piling up of terrestrial clods, at least so far as their backbone is concerned. It is only this backbone which consists nowadays of pristine rocks that were once upon a time deposited on the red hot surface. The massive granite, however, is covered by strata which can have been deposited only by water. For the water is playing a very essential role in building up the present aspect of mountains. The forces of fire, which we have studied so far, are now relieved by the circulation of water. We observe its many effects all around us.

We have seen that the condensation of water out of the atmosphere is in every respect similar to the process by which the first liquid shell of a world-body is formed, with this exception that the fiery liquid develops a series of aggregate masses from the bottom up and in a direction opposite to the hitherto prevailing one. A vast atmosphere extends over the red-hot liquid, just

THE MAKING OF THE WORLD

as we still see it in the case of the sun. On either side of this fiery liquid there are strata of gases, above it as well as below it, and the atmosphere above it is supplied from that below it by permeation, just as we see it in the case of volcanoes and lava. Rain may have fallen for thousands of years out of that dense atmosphere, and yet no drop of it could reach the surface. But at last boiling water was collected in hollows. Then began the fierce duel between fire and water, which has not yet been settled, although we plainly foresee the outcome. The hot ponds and lakes developed into oceans, and finally the entire globe was surrounded by water. From now on the succession of aggregate conditions is completely subverted, beginning with its solid shell. Its interior has remained gaseous, and is surrounded by a layer of red hot liquid. This, again, is surrounded by a solid crust, which in turn is covered by a layer of liquid, the oceans, and ultimately we have a layer of air, the atmosphere. However, we must not forget, if we wish to understand this peculiar arrangement, that the density and weight of these different aggregate conditions continually increases from the outside toward the inside.

Some ridges of the primitive rocks may always have reached above the hot seas. For the geolo-

THE MAKING OF THE WORLD

gists distinguish rocks which show the influence of oceans from pristine periods. The hot waves broke upon these rocks and wore away as much of them as possible. The oceans were saturated with mineral elements. But the cooler the water becomes, the less it can hold of soluble substances. The continuous cooling process in the oceans, then produces similar phenomena as the gas ball of the sun and our atmosphere, that is to say, precipitations take place, sediments are deposited on the bottom of the ocean, including some which consist of earthy substances, which were carried into the sea by the mechanical effects of the surf or of rivers formed on the land. Such precipitations still take place today. We call the layers thus formed *sedimentary strata*. Originally covering the bottom of the seas, these strata are lifted out of their wet grave by the movements of the solid crust, the causes of which we mentioned a while ago. Frequently we find them horizontally deposited in the mountains. They are still the same that they were when first formed, only they may be thousands of meters above the surface of the seas. More frequently these strata are shoved far out of their original position, strongly compressed, or torn asunder. Thus they plainly show that the crust of the

THE MAKING OF THE WORLD

earth moves up and down in the course of ages, and that there is nothing constant in the eternal process of the universe. These creases in the rocks may be easily studied on the romantic shores of Lake Uri, Switzerland, when wandering along its precipitous side on Axen road to Fluelen.¹²

How could such creases be formed? Just as a piece of cloth is folded, when shoved together. Owing to continued cooling, the earth became smaller, like any other body which cools off. Then its tough skin became too wide and folded up in creases. Slowly the sedimental strata were lifted out of the oceans and shoved along the massive rocks of the primitive mountains, like waves on the shore. Frequently they were pushed so high that they toppled over like the crests of waves. They settled over one another in the reverse order of their stratification. In this way new conformations of mountains arose. The wearing effect of atmospheric precipitation added its share of work. These precipitations could attack watery strata much easier than those which had been hardened in the primitive fires, and thus the tops of the primordial mountains were more and more freed from the sedimentary strata which covered them. For this reason most

THE MAKING OF THE WORLD

of the high mountain chains show today the following structure. Their highest peaks consist of primitive rocks, granite, gneiss, etc., and on either side of them the heads of sedimentary strata join them, the oldest of them being closest to the rocks. But only rarely these strata are symmetrically arranged on both sides of the rocks. For instance, in the Alps the sediments rise but gradually in extended foot hills on the northern slope, but on the southern slope, especially toward the plain of the Po, which was a sea a relatively short time ago, the massive granite rises steeply from the shore. At this place, a landslide took place similar to that on the Pacific coast, and this region, like the Pacific, was a volcano. Only narrow strips of sedimentary strata stretch along the foot of these mighty mountain walls of pristine rock.

These sediments were gradually corroded into valleys by rivers. At first the simple forms of the mountains were thus traversed by a network of cross and longitudinal furrows. The water thereby helps to complete the circulation of the solid parts of the earth. It carries them back into the seas in which they originated and out of which they were once lifted by the forces that build mountains. But the granite backbone of the high

THE MAKING OF THE WORLD

mountains is but little affected by the water itself. Since it was not born in the water, granite withstands those corrosive influences. It requires more powerful agencies to fell the stubborn granite giants. They succumb, however, to the explosive action of ice, which destroys everything. The high mountains are covered with ice and snow which grind even the hardest granite into round blocks or cut deep fiords into them, wherever fields of ice glided down to the seas. The interaction of the upbuilding forces of mountains and the corrosion of the water gave to the surface of the earth gradually a great variety. This play of interaction still continues ceaselessly today. We can see with our own eyes that the rivers are carrying mountains into the plains. On the other hand Penck has found plain indications that the Alps are being lifted all the time. The "eternal" snows on these rigid peaks are but like the froth of heaving billows for a mind that sends its glances across geological ages and passes over milleniums as though they were seconds.

In the primitive ages of the earth's history, in which continents, mountains, and oceans were formed, there was still a heavy atmosphere, impenetrable for celestial light, extending above

THE MAKING OF THE WORLD

the globe. Only the eruptions of volcanoes and the streams of lava lighted the landscape, which consisted of steaming water and land. No living being could grow here. The air was as yet filled with stifling mists, which came out of the volcanoes and contained doubtlessly a great deal of carbonic acid, a deadly poison for all animals. It is true, that carbonic acid is, on the other hand, the essential element for the life of plants, just as oxygen is for us. But plants require also light, and this had not yet appeared on earth in those primordial days. Perhaps there was no sun, then, or at least it shone but feebly in its misty state of generation. At any rate, its rays were unable to penetrate the heavy atmosphere of the earth. We must remember that at least five hundred million years have passed since our planet passed through that period, and we do not know in what condition the sun and the other parts of its system were at that time. Our foregoing description makes it plausible that the sun was much larger than it is today, but less luminous and radiating less heat. The central world to which we owe everything that nature offers to us was then of little importance for our globe. Even though this world-body in the center of its system compelled our planet to circle around it in

THE MAKING OF THE WORLD

a time corresponding to our present year, the darkness of this dreary period did not disclose this fact. The earth did not need the sun. Our globe had still enough heat of its own, it was itself a sun nearing extinction. No seasons, no zones, no change of night and day existed in that epoch of terrestrial development which is called the archaic period by the geologists. This is the period in which those primitive rocks were formed which we have mentioned so often, and which are found everywhere in the lowest depths of the earth all around the globe. Never has any trace of organic life been discovered in those rocks.

The strata of archaic rocks pass in some places by imperceptible degrees into stratified minerals which must have been deposited under the influence of water. And these so-called *Cambrian* strata are the first to disclose the presence of relics of a very precarious life. The forms of this life differ widely from those now seen in the nature about us and belong mainly to the deep sea type, so that one is tempted to think that life first originated in the dark depths of primitive oceans.

But how could it get here? How could it arise at all on the newborn world-body, which had been flooded but a short while before, by

THE MAKING OF THE WORLD

fierce oceans of fire that would have destroyed, without fail, the very last germs of life, provided that any should have been contained in primitive matter?

Perhaps by *spontaneous generation*? This is the most difficult of all questions to answer. We can touch upon it but lightly at this point. In another volume of this library, entitled "The Evolution of Man," Bölsche has already handled it in his masterly way. He takes the position that a spontaneous generation, that is to say, the generation of the first organic cells out of so-called inorganic substances, actually occurred on earth as soon as the moment was auspicious, the moment in which the requirements of organic life, such as a certain temperature, water, air, etc., were available. The great difficulty at this point is that we have been in the habit of attributing to living things a fundamental faculty which was supposed to distinguish them radically from the forms of so-called dead nature. This is the principle of *sensation*. We can trace all external phenomena of nature to movements, chemical processes, etc., or at least we see our way clear to such an explanation, but feeling, consciousness, which must necessarily be present in its most elementary form even in the very lowest living things, can

THE MAKING OF THE WORLD

never be explained out of movements. Bölsche and others overcome this difficulty by attributing feeling even to so-called dead things from the very outset, so that according to them there is no such thing as dead matter in the universe. However, that form of feeling, which we observe in living things, does not appear until certain definite requirements are first fulfilled. It follows, that under such circumstances even a stone would feel when I kick it, of course only in a very imperfect manner. A stone has no organs by which it might manifest feeling. Even plants, that intermediate product of vital development according to this conception, have but very imperfect organs for this purpose, so that they were for a long time considered devoid of sensation. There is nothing valid that can be said against such a conception. At least there is no reason to doubt the probability of such a thing. One might even go further in this, following in the steps of that imaginative writer who declared all world-bodies to be living beings, cells of a larger common body. So-called dead matter is the bony skeleton, and we living beings are the cells which cluster around the great nucleus of the earth, and so forth.

The only drawback of Bölsche's conception is

THE MAKING OF THE WORLD

that it cannot be proved any more than it can be disproved. He says explicitly that we shall never be able to perceive expressions of life in a stone, and therefore we can never ascertain whether it really has any sensation. It is true, and Bölsche explains it very nicely, that this way of solving the great question obtrudes itself almost irresistibly, when we reflect that everything else in the universe has developed from the simple into the complex. This applies to world-bodies, living beings, sensation, so far as we are able to observe it, consciousness, the intellectual life of man, and everything else. And yet there are some who imagine that things should have taken a sudden leap, that a miracle should have happened at a period when the earth had become sufficiently cooled; that spirit, born of nothing, for it was not on the burning earth before that should have lodged itself suddenly in the rigid stone and transformed that clod of earth into the first amœba, the first germ of life, which henceforth could develop freely into a man! The entire evolution of the universe required but this one miracle. All other things which took place before and after it were generally explicable, although much of it still remains to be clarified. The theory that even a stone contains the rudi-

THE MAKING OF THE WORLD

ments of consciousness does away with the necessity of a miracle, and renders the entire structure of the universe still more uniform than before.

All this is much like a confession of faith. Neither side can substantiate its theory by proofs. It is true that we find all the great principles of development, which created the world of life, just as well in so-called dead nature. It is not the naïve imagination of the ancients alone which attributes the genesis of the universe to the love and hate of elements. The attraction of matter, the irresistible love of the stone for its kind, created this beautiful, wondrous order of the planetary empires out of the chaos. And if we were to limit ourselves to poetical language with reference to matters which we cannot prove, we might discover in the world of atoms manifold traces of graduated sympathies and antipathies, which strikingly resemble the manifestations of a sort of soul-life.

But of course, all this is but the work of phantasy. It seems to me that the need of further explanation is not done away with, even if there were some truth in this imagination. The wonder in the faculty of individual sensation and mind, which so widely distinguish the beings endowed with them from the remainder of

THE MAKING OF THE WORLD

nature's products, is thereby transferred merely to a deeper level and to a latent state, which we cannot explain any better than the active principle of mind.

But is it necessary at all to assume the creation of mind? Could it not have been present from eternity, the same as matter and its ceaseless motion? If we admit that motion can never be mind, that the arbitrary motions which matter executes in and by living beings are but expressions of the higher power of mind by which the otherwise unalterable forces of nature are guided, then we obtain a third element in the creation of the universe. This third element alone enables the universe to fulfill its highest missions. And it must have been present from all eternity the same as the other two elements, matter and its motion.*

*The reader will notice that Dr. Meyer does not intimate here that his third principle, the guiding principle of the universe, is a supernatural entity. He simply classes it with the other two natural elements, matter and motion. He claims, indeed, that it is superior to these two elements, but evidently this superiority is of the same kind as that of the human brain over the central nerve system, and that of this nerve system over the muscles. But in other passages of this work the author swerves from this standpoint and introduces a metaphysical spirit into the discussion. The reader therefore remains in doubt about the author's position on this vital point. It is evident that Dr. Meyer does not solve "the great puzzle," but simply

THE MAKING OF THE WORLD

It is strange that many otherwise excellent thinkers should have had so much difficulty with the assumption that the miracle of the spiritualization of dead matter should have taken place on earth. For the difficulty exists only so long as we regard our planet as isolated from the remainder of the universe. We still meet in this alleged difficulty the relics of the pre-Copernican thought that the earth was the center of the universe and that everything all around this globe was unessential and had no determining influence on our destinies. Today we regard the earth as a vanishing particle in an endless and intimately interwoven universe, built in all its parts on a uniform plan. But only a few, who occupied themselves intensively with this subordination of ourselves under one great universal principle, and who thereby gave all our meditations an entirely new direction, have been able to overcome fully that pre-Copernican point of view.

Now, if we draw the logical conclusion from this new premise as to the question of the genesis

transfers it to eternity, which is equivalent to giving it up and admitting that his science has no explanation, but only, as he says himself, on the preceding page, "a confession of faith." Readers interested in the solution of this puzzle are referred to the works of Joseph Dietzgen.—TRANSLATOR.

THE MAKING OF THE WORLD

of life on earth, we must admit not merely the *probability*, but the *necessity* of the existence of the elements of life, like that of all other elements required for the process of universal evolution, from all eternity. These vital elements must have spread from world-body to world-body and fertilized them all. But if this is a necessary premise, then we have no longer to grapple with the question, whether there ever was such a thing as spontaneous generation, nor with that other, whether life is latent even in a stone. Those who adhere to these theories *may* be right, nevertheless. But at any rate we can dispense with the idea of spontaneous generation.

We have only two assumptions to prove, in this case. First we must prove that life existed on other planets, and in the second place, that it can be carried to this planet. The first assumption can never be strictly proved, for I doubt that our optical instruments will ever be so strong that they can discover indubitable signs of life on other planets. The canals of Mars, and similar things, will always remain doubtful testimony. On the other hand, we are certainly not entitled to the assumption that in all this vast universe the earth alone, an atom in the infinite, should have the exclusive privilege of generating and

THE MAKING OF THE WORLD

harboring life. This would be a completely pre-Copernican assumption. In any case, we can prove that in such an event the earth *must* have fertilized the remainder of the universe if all the rest of this universe had really been dead. The germinal spores of the minutest living beings, the bacteria, are so small that they must occasionally leave our planet and its sphere of gravitation, when carried to the highest regions of our atmosphere. Then they must swarm through space. It has been demonstrated that the pressure of light alone is sufficient to carry them from one planet to another. It has been shown, furthermore, that these germs, and even the germs of higher organized beings, can endure the cold of space without injury to their vital power, which will develop as soon as they find the necessary conditions for it. If they get into the sphere of influence of some world-body related to their birth-place, even after immeasurable periods of time, then they *must* fertilize it. This answers in the affirmative our second question, that of the transmissibility of life from world-body to world-body. And if the earth can awaken life on other world-bodies, then it must also have received germs of life from them. Life *must* have rained down upon us from heaven.

THE MAKING OF THE WORLD

This took place at all periods, and it is still taking place. Only, none but the very minutest germs can reach us in this way, under normal circumstances. That kind of germs are found everywhere in our air. Nobody can testify to their descent. Every microscopical preparation may contain hundreds of such immigrants from the remotest regions of the universe.

So long as the surface of the earth and its atmospheric shell were too hot, these germs were killed. Gradually they survived, first in the highest regions of the air nearest to cold space, and the rain carried them from here to the surface of the earth. Wherever the solid ground projected above the seas, in the first periods of germinal emigration, it was doubtlessly still too hot to enable even these unpretentious germs to develop. But the seas had generally a somewhat lower temperature, even on their surface, because they were continually cooled by atmospheric precipitations. The lowest temperature, however, was found in the depth of the seas, in which the coldest water settles because it is the heavier. For this reason the solid crust of the earth would cool off most rapidly under the seas and become thicker there than under the continental agglomerations. The bottom of the seas soon became

THE MAKING OF THE WORLD

more resistant against the pressure of volcanic eruptions than other regions, so that conditions became more peaceful here. Contrary to all expectation, the conditions favorable for the development of life were first present at the bottom of the seas. The depths of the seas are to this day as dark as they were then, and for this reason it was doubted for a long time that any life could exist there. For all life, even the very first, on any world-body organized even remotely like the earth, needs light directly and indirectly. All animals, even those at the bottom of the sea, can live in the last resort only from plants, and no plant grows without light. But vegetable nutriment is carried into the dark depths of the oceans by the *plankton*, minute living beings swimming in the oceans. In the depths still reached by the light, algæ, that is to say plants, mingle freely with the plankton. None of these things reached the ocean by way of the land, all of them belonged to the waters. If the first germs of life really came out of the universe outside of the earth, they found in the highest regions of the earth's atmosphere all the requirements of their development, provided a sun existed then. And in the same way the plankton of the seas found its requirements of life ready

THE MAKING OF THE WORLD

at hand in due time. The *atmospheric plankton* sank with the rain into lower strata of the atmosphere and spread the life in them, even if no light could penetrate so far. And finally it reached the bottom of the seas. Even on the surface of the solid crust animal life could spread, provided only that the temperature had become bearable.

In keeping with these assumptions, we find indubitable traces of a low animal life only in those strata of the solid crust of the earth which were deposited by the primitive oceans directly over the crystalline rocks. Higher up we find plain evidences of deep sea forms. All these first animals were blind. There was no light in their world, and it seems that they had not yet invented that self-luminosity which is exhibited by our present deep sea animals. The most highly developed beings of this *Cambrian formation*, which is the lowest stage of the *Palæozoic Period*, are the *trilobites*.¹⁸ They are deep sea animals of the crawfish class, resembling woodlice. These ugly-looking creatures must have been very abundant in the pristine oceans, and only a few species of them must have existed. Large masses of them are found in a fossil state in the strata of that period. The hard shell of these primitive crustaceans and the peculiar proc-

THE MAKING OF THE WORLD

ess of fossilization preserved them for us through passages of time which surely are measured by millions of years. Such trilobites no longer exist in our present oceans. On the other hand, fishes did not exist in that period. Life, molded into repulsive forms, crawled about on the dark bottoms of the primitive oceans. There was as yet no trace of any land animals or plants. Probably there was no inhabitable land at that period.

But to the extent that we ascend into higher strata of the earth's surface, we meet with more highly developed forms of life and notice that the growing tree of life branches out into a greater variety of organisms. And it could not be otherwise. Since there was a time when life did not exist on earth, it could expand only step by step, no matter by what means. Whether living organisms developed into higher species through the struggle of existence with their kind, as Darwin assumed, or whether they adapted themselves to the successive changes in their conditions of life, such as the fall of the temperature, the extension of dry land, and its manifold transformations, as Lamarck assumed, in any event their rise had to be gradual.

So we see in the *Silurian* formations, which are located directly above the *Cambrian*, a

THE MAKING OF THE WORLD

greater variety of species of trilobites than before, and their forms are better developed. They have the first rudiments of eyes, although the eyes themselves have not yet developed. Life was born blind, just as many animals are to this day, but it was gradually prepared for sight. In the median strata of this formation we meet with a genuine lobster, which has large eyes, while it is otherwise still rather clumsy.¹⁴ This does not necessarily indicate that the light of the sun penetrated to the depths in which these animals lived. It is rather more probable that the luminant deep sea animals had developed by this time. We meet with glass-sponges and sea-lilies, similar to those which we still find in our own day. Furthermore we find in those median strata of the *Silurian* period a great variety of molluscs, snails, octopus-like species of nautilus, starfishes, sea-urchins. And in the highest *Silurian* strata we find even fishes. At the same time we meet with marine plants, such as algæ, and there are also relics of land plants which indicate that the first light was then penetrating to the surface of this globe. Along with these organisms, we discover in these strata the lime and silica shells of radiolaria and foraminifera, which still constitute today the main portion of the

THE MAKING OF THE WORLD

plankton, precipitated out of the world of light into the mysterious depths of dark and cold ocean regions, and nourishing their life.

Above the *Silurian* strata we find the *Devonian*. Here the fossil remains tell of more perfect organisms than in the lower strata, but nevertheless these strange forms represent as yet a very poor life.¹⁵ Not one of those forms resembles any now living. Fishes, still scarce in the *Silurian* developed very strongly in the *Devonian* period. Life rose from the bottom of the seas and expanded in all three dimensions through the open waters, from which it had at first descended as a fertile rain of germs. The bottom of the oceans was thus the womb of all living things.

Among the fishes there appeared at that period the shark, a member of that low genus of cartilage fishes which has eaten its way through all the ages of creation. Such a predatory race is hard to overcome.

The land must have become a little more inhabitable at this period. Land plants appear sparsely. Together with them a few species of insects were seen, but only such as even nowadays love dark and warm places, for instance cockroaches. So the atmosphere must have been still gloomy and heavy.

THE MAKING OF THE WORLD

After that we suddenly encounter a tremendous improvement. In the *Carboniferous* strata we come across giant weeds. These are found all around the earth and their luxuriant masses were active in building our coal deposits. Evidently this rank development of the plant-world took place very rapidly. The young continents, heretofore so desolate, covered themselves suddenly with a dense growth of verdure. We may well understand that. The young soil was still warm, and above it hovered a heavy atmosphere which did not permit the warmth of this soil to evaporate quickly into space, any more than a roof of opaque glass would. The conditions were like those in a hothouse, except that light was wanting or insufficient. But no plant can thrive without light. This is the most indispensable of all requirements of plant life. Light alone accomplishes the miracle of awakening dead matter to life. Light builds up from the inert atoms of inorganic soil a sentient living being, provided that this soil has first been impregnated with one of those mysterious vital germs, which we have seen speeding through the universe and scattering the happiness of sensation. Life desires light. Although we have seen that there are some beings that do not care for the light them-

THE MAKING OF THE WORLD

selves, still we know that they all live on plants, directly or indirectly. This life-giving light was wanting hitherto on the surface of the globe. But as soon as the crust of the earth closed in about its center, so that the fiery magma could no longer send large masses of obscuring smoke and ashes into the air, the light of the sun was able to penetrate. From now on the surface of the earth presented the spectacle of a huge hot-house. The growth of plants was favored, among other things, by a far greater amount of carbonic acid in the atmosphere than is contained in it now. It is well known that this gas is still exhaled by the interior of the earth through volcanoes. The plants possess the faculty of assimilating the carbon from this gas, which is a poison for the animal-world, and to set free the oxygen, the vital element of animals. The carbon in the plants is indeed bound to other elements, but these were set free by the slow process of distillation during the disintegration of the plants in the swamps in which most of them used to thrive at that period. In this way the swamps gradually became reservoirs of almost pure carbon, which enables us even now, after millions of years, to utilize the power of the first sunlight which fell upon the young earth. In those days

THE MAKING OF THE WORLD

this splendid light had primarily the duty of producing a rank growth of plants. For only comparatively few land animals existed then, probably because the excess of carbonic acid in the air was injurious for them. The plants thus performed the task of purifying the air for the subsequent development of a higher animal-life on the land.

The plant-world of the *Carboniferous* period consisted mainly of giant ferns, mosses, shave-grasses, which still vegetate today in swampy regions as degenerate representatives of a time in which their powerful ancestors dominated the earth.¹⁸ They still avoid the direct sunlight as much as possible. It seems, then, that but a dim light penetrated the still murky atmosphere of that period. No plant of that age produced any blossoms, for the beautiful variety of colored flowers can be born only in bright sunlight. The plants of the *Carboniferous* age belonged exclusively to the low order of cryptogamous vegetation, which shield their germs against the light. Of this class are the ferns, which hide their fruit under their leaves and expose them so much more to the warmth coming from the soil.

Along with these herbaceous plants, which grew to a giant size, the vegetation of this period

THE MAKING OF THE WORLD

shows the first pine forests, that is to say, real trees which have likewise maintained themselves to this day, although in different species. Indeed, they are still the predominating class of trees. Palms or deciduous trees did not yet exist.

These primeval forests of giant weeds were inhabited by some little developed animal life represented mostly by insects. Especially white ants of large size, which still live in the tropics, were then building their art structures in the green gloaming of that queer time. It seems as though intelligence, which in a general way developed in the evolution of animal forms, was destined to reach its highest summit in the class of insects. We know that ants, bees, and other insects, have many traits of advanced faculties. But in the course of events it was found that this branch of the tree of life, although relatively high in the scale, was not capable of further development, and that another branch would grow beyond it, spreading into a magnificent top.

Together with white ants and other insects, which still prefer darkness and bad air, this period also produced some higher developed swamp-dwellers, newts of the *Stegocephalus* kind. These had evidently developed out of fishes. The life of the oceans crawled ashore,

THE MAKING OF THE WORLD

assuming at first forms which could live in both elements, but preferred the water, in other words, amphibians. Genuine reptiles were not present at that period. All these forms were unostentatious. The animal-world still played an insignificant role ashore, while it filled the waters with a variety of ever more perfect forms. But no new classes of marine forms were produced after this. If we make exception of the marine mammals, whose ancestors evidently lived ashore and were crowded back into the sea at a later epoch, we find that the marine animal-world did not send out any new branches after the fishes, but merely modified the existing forms. It is noteworthy that from now on the marine fauna becomes much more rapidly similar to that of the present age than the land animals. This is easily explained by the fact that the conditions of life in the oceans have changed much less since primeval times than those on shore. Consequently there was less necessity for new adaptations leading to new forms.

In the development of life during the *Carboniferous* period, there is one peculiarity which excites wonder. We find coal deposits in all latitudes of the earth, from the most southern to the extreme northern. And everywhere it was the

THE MAKING OF THE WORLD

same plants which grew equally rank in the tropical and in the polar regions. Now this seems impossible from the point of view of present conditions on earth. Even though the general circumstances connected with this period produced a hothouse temperature all around the earth, owing to the heat in the interior of this globe, still those plants required some sunlight, however dim. But this would be absent for many months in the polar regions, provided that the position of the earth's axis was the same as now. In that case no such vegetation as that of the *Carboniferous* period could exist in those regions. But we actually find well developed coal on Spitzbergen, and a recent Belgian expedition discovered fossil remains of a former luxuriant vegetation in the vicinity of the South Pole. No matter how much we turn the axis of the earth around its present position, we do not get away from this difficulty so long as we assume its position to have been fixed. There would be always some region which would be temporarily or permanently without light, and a necessary corollary is a classification into zones, which evidently did not exist at that time. Some have tried to resort to the explanation that in those days, several hundred millions of years

THE MAKING OF THE WORLD

ago, the entire solar system may have had a different construction. For instance, there may have been several suns. Of course, it is always easy to resort to such expedients, for they cannot be proved or disproved. However, it may well be admitted that the solar system was indeed differently constituted in those days. And this may be so in spite of the fact that modern astronomers claim its present constitution to have become almost infinitely stable. In that case it has passed into stable conditions which did not exist in former ages. But if we follow this road too far, we get into unfathomable regions.

If we take our departure from tolerably known premises, then only one possibility remains for the explanation of primitive conditions of temperature, which become still more mysterious in subsequent periods of terrestrial evolution. The axis of the earth must have had a different position than nowadays, and the poles were located in regions which have not been geologically investigated so far. For instance, if the North Pole of the *Carboniferous* period was situated in a region now occupied by the interior of China, which has been little explored and certainly has not revealed any coal deposits so far, then the South Pole would also have been in

THE MAKING OF THE WORLD

regions which are not accessible to exploration. That would imply a wandering of the poles from their primeval to their present position. This may have taken place gradually or suddenly. We mentioned previously the probability of a sudden dislocation of the terrestrial axis by a collision with some cosmic body. But it is also possible that this displacement may have proceeded gradually, carrying the poles in a spiral across the surface of the earth. It is true that, until a few decades ago, the position of the earth's axis was regarded as the only constant thing in nature. But in the meantime oscillations of the axis have been observed beyond a doubt. The causes for these oscillations can be located in our day only in slow migrations of terrestrial masses, such as may be originated by eruptions of volcanoes, earthquakes, and tectonic movements of the earth's surface in general. It seems as a matter of fact that the degree of the polar oscillations at any time is corresponding to the violence of the volcanic phenomena. Such mass movements were no doubt far more noticeable in primitive times than today, and it may be that their direction was for a long time such as implied a progressive precession of the poles. By this means all parts of the globe would have



THE MAKING OF THE WORLD

been transferred to the various zones in succession, and no region would have been held permanently in the rigid cold of the polar zones which prevented them from serving in the propagation of life. Such an eternal circulation of events is long recognized to be the supreme principle of all natural processes. The migration of the poles across the entire surface of the globe is the only natural solution of the great problem of primitive conditions of temperature.

This precession of the poles may also be the cause of the remarkable fact that the luxuriant life of the *Carboniferous* period was followed by a stage of universal impoverishment, which is known as the *Permian* period. The tree of vital development continued indeed to grow during this stage. The amphibians of the *Carboniferous* stage were followed in the *Permian* by slightly advanced reptiles. But the tree of life began to shed its leaves. It was as though a period of hibernation was impending, in which nature was husbanding its resources. We shall meet another similar period of universal decline later on just before the present age, in the *Glacial* period. The *Permian* period did not experience a complete glaciation, but it bears some traces of ice nevertheless. Perhaps the earth

THE MAKING OF THE WORLD

had still enough heat of its own to prevent an extended glaciation, even around the poles of that period. It has long been assumed that the deposits of that period, such as red sandstone, mine stone, and others, carry few relics of life, because in the course of development they were formed in less favored localities, and that further research in hitherto inaccessible territories might disclose the presence of abundant life also in these strata. It may be that the poles were wandering at that period close to such regions and left them devoid of life.

The *Permian* period closes the era of *Palæozoic* formations. With the following, the so-called *Trias* formation, we enter the *Mesozoic* period. This formation, so far as it is next to the red sandstone, is still very poorly equipped with life's relics, although they show a perceptible improvement in this regard. The two upper strata of the *Trias* formation, the shell marl and the chalk, bear evidences of a strong forward development. The reptiles increase enormously in species, in numbers, and in size. The powerful saurians appear, such monsters as the *Ichthyosaurians*,¹⁷ *Plesiosaurians*,¹⁸ etc., which reached their highest development in the *Jurassic* period following the *Trias*. These saurians

THE MAKING OF THE WORLD

are intermediate forms between fishes and lizards. Some of them still had the queer eyes of the deep sea fishes, showing that sunlight did not yet shine very brightly, or that the seas were very turbid. These saurians surely were no genuine deep sea animals. For we know that reptiles have lungs, which compel them to breathe air, although they may be without it for a long time.

In those days, the first mammals put in their appearance. The highest and most beautiful branch of terrestrial life began to germinate at this time. But it remained small and unostentatious, so that no one could have recognized its great importance. It was represented by a few marsupials, the lowest stage of mammals.

The plant-world had not changed its forms very noticeably from those of the *Carboniferous* period, but it had lost its luxuriance. Even now there were no flowering plants and no deciduous trees. However, the ferns, shave-grasses, etc., while still existing, no longer dominated the landscape. Pine forests developed more vigorously, and evergreen plants, such as palms, appeared. The geographical distribution of such plants did not show any classification according to zones. Fossil remains of palms are found also in our present polar regions. It is certain,

THE MAKING OF THE WORLD

then, that the entire surface of the earth enjoyed a higher temperature than now.

Now, if we ascend to the next formation in the scale, the *Jurassic*, we meet once more a climax in natural evolution, which produced the most hideous monsters among the reptiles, animals that look as though they were the offspring of a diseased imagination. Just take a look at the *Ceratosaurus* in our illustration!¹⁹ This animal, resembling in a general way a kangaroo, reached a height of seven meters when erect, that is to say five times the height of a man. A prominent place among the reptiles of this period is occupied by that winged dragon, the *Pterodactylus*, a flying lizard.²⁰ Nature had made a first timid attempt to conquer the air for its organized life by means of winged insects, just as it had conquered the waters by starting out from the bottom of the seas. But these insects did not venture beyond a narrow zone, and they were not conspicuous forms. Now the creative and incessantly busy force of nature advanced more boldly into the airy regions. It attempted to create a being which should be equally well at home in all three modes of motion, which should be a good swimmer in the water, a good walker on shore, and a good flyer in the air. If a large animal was to

THE MAKING OF THE WORLD

learn how to fly, it had to be a good swimmer. For if the first attempts at flying should result in failure, a heavy body might easily be killed by a fall. Human beings who nowadays make attempts at flying, also prefer to do so over a lake, in order that the yielding element of water may ease their fall in case of accident. And if nature intended to develop reptiles into birds, then it could do no better than to teach reptiles how to fly. Thus arose that terrible flying lizard, which must have been the greatest terror even of that time so full of horrible shapes. Our illustration shows a skeleton of this monster. Between its body and one of its long fingers armed with sharp claws there was stretched a skin similar to that of a bat, which served as a support and means of flight. Between these two wings, a horrible head with the jaws of a crocodile was attached to a long neck. Some species were also supplied with a long tail which added to the uncouthness of their form. Just imagine a flying alligator hurling itself, like a giant bat, or a fabulous vampire, out of the air upon its victim and enveloping it with its nasty and clammy flying skins.

And yet this most horrible of all animals created by nature, this monster preying in all ele-

THE MAKING OF THE WORLD

ments, was unable to acquire the supremacy in any of them. It was as though nature had attempted too much at one time. And it is a matter of common experience that he who would pursue several aims simultaneously will never accomplish as much in any one line as the specialist. So it seems that flying lizards, or flying reptiles in general, were failures. Nature did not continue its experiments along this line. These forms very soon disappeared in the subsequent geological periods.

Nevertheless this venturesome and ugly form was a necessary stage of transition to the beautiful and merry race of birds, the dwellers of the air. We have seen that nature could teach animals the art of flying only over the waters. Faculties acquired in the struggle for existence are inherited. So the flying reptile was gradually transformed into a reptilian bird, of which *Archæopteryx* was a type. This animal embellished itself with feathers while its head had still a reptilian shape and was provided with reptilian teeth. Only two specimens of this bird have so far been found in a fossil state. The illustration in this book is made after a specimen preserved in the Berlin Museum of Natural History.²¹

If a genuine bird was to disport itself in the

THE MAKING OF THE WORLD

air, then the atmosphere had to be comparatively pure and clear. No bird can move in a murky or misty air without risking injury by flying against solid objects which it perceives too late to avoid them. However, conditions on this globe now approached more and more those of our own age, at least so far as general principles are concerned, while the individual forms were still considerably different from those of the present day, especially their organic development being still imperfect. The *Jurassic* period has left us relics of but very inferior mammals. It had neither deciduous trees nor flowering plants.

So far as we have been able to ascertain by exploration, the temperature of that period was still uniformly tropical. There were no indications of any classification in zones nor of seasons. Deciduous trees represent a necessary adaptation to such changes of season. The same applies also to animals with warm blood, which were not yet in existence. By the way, it is incorrect to call reptiles and amphibians cold-blooded animals. Their temperature is that of their environment, which in our latitudes is, indeed, below that of our blood. But in the tropics the temperature of reptilian blood is almost the same as that of our own blood. At that remote period, in which

THE MAKING OF THE WORLD

the temperature was still universally tropical, all animals were warm-blooded. However, below a certain temperature the protein of the animal body coagulates and the circulation stops. Animals which are not so organized that they can maintain their bodily temperature by their own devices above a certain degree become sluggish and finally rigid. They fall asleep during the winter and remain in a deathlike torpor. The reptiles of that period never had to face such an eventuality, and for this reason they developed abundantly. But when a change of seasons took place, new forms had to be created, which should be able to live actively through the winter. Naturally these forms gradually outstripped the others. The change of seasons, which became more marked through the progressive cooling of the earth's crust and the clarification of the atmosphere, was instrumental in creating warm-blooded animals and ultimately man arose out of them as the crown of creation. The warm-blooded animals, who were not by far so well armed as the reptilian monsters, rose to supremacy because the coming of winter delivered these giants helplessly into their power.

However, before this fundamental transformation took place, another geological product inter-

THE MAKING OF THE WORLD

vened, the *chalk*. Its strata consist mainly of huge deposits of those minute living beings which swim in the free water of the oceans. These are the so-called *foraminifera* and *radiolaria*, whose chalk and flint skeletons constitute to this day the greater part of the muck of the seas. The fossil remains of that period show that life was in a process of constant development, also in the oceans. The fishes, which first had a hard shell like the crustaceans that were their ancestors and which had only cartilage for the solid support of their bodies, gradually acquired a bony skeleton like the most perfect species of fish in our day. We have already mentioned that the primitive life of the sea approaches the living forms of the present much more rapidly than the primitive terrestrial forms do, because the conditions of existence in the seas have been modified far less than those of the land. Indeed, after the establishment of geographical zones had permanently covered the poles of the earth with ice, the conditions on the bottom of the seas tended to become constant, for now the densest water produced by the melting of the polar ice, at a temperature of 4 degrees above zero, continually flowed over the bottom of all seas and kept it at about this same temperature all around the globe.

THE MAKING OF THE WORLD

In other words, there is no classification into zones in the depths of the seas now, and there never was any. We have good grounds for assuming that caps of ice permanently gathered at the poles during the *Cretaceous* period, and for this reason the animal-world of the chalky seas was not materially altered compared to that of our own period. It is thought, for instance, that a few of the giant saurians, such as we find fossilized in the chalk, are still living in the depths of our oceans. The famous sea-serpent is declared to be no mere phantasy. Repeated reports concerning this marine monster are said to agree too well and to indicate the existence of such a reptile of the dim primeval ages, one of those rare specimens which saved themselves by taking their refuge in the darkness of the oceans.

The establishment of distinct seasons is also indicated by the fact that these sediments show the first remains of deciduous plants. This was an extraordinary progress of plant-life in the direction of the vegetation of the present.

The fact that no remains of mammals are found in the chalk does not prove their entire absence at that period, because these strata were mainly deposited in the seas of that age. But it reveals at least that mammals were of little importance in

THE MAKING OF THE WORLD

the total make-up of the animal life of that period, and that they had not made any marked progress from their earlier stages.

But suddenly the day of our present creation breaks as gloriously as a sunrise in the tropics. We enter into a new period, the *Cainozoic*, which stands in marked contrast to the preceding, the *Mesozoic*.

The first division of the *Cainozoic* period is called the *Tertiary* formation. It is subdivided into the *Eocene*, which is the dawn of the new age, furthermore the *Oligocene*, the *Miocene*, and the *Pliocene*.

It is this *Tertiary* age, in which those tremendous terrestrial revolutions took place which gave birth to most of the great mountain chains of this globe. Whole rows of volcanoes sprang up in the course of this upheaval, and the geographical aspect of the surface of the earth approached that of our time.

The struggle against such fundamental terrestrial revolutions necessarily transformed the living beings engaged in it. Among plants we see flowering forms unfold with great vigor, a proof that sunshine and spring had come. During the first stages of the *Tertiary* period the new plants, which belong nowadays mostly to the temperate

THE MAKING OF THE WORLD

zone, grew still side by side with tropical ones. Our regions enjoyed still a subtropical climate, then, which reached far beyond the present polar circle. I have collected the fine large leaf shown in our cut in the *Tertiary* strata of Spitzbergen, where the sun does not rise for three months and where deciduous foliage is represented by a stunted birch hiding among the moss.²² But the remains in the higher strata of the *Tertiary* formation show clearly that the conditions of temperature and the gradation into zones became more and more similar to those of the present day. Everything pressed forward into our own beautiful age.

Accordingly the monster reptiles suffered a setback, as we indicated before. The warm-blooded animals developed in their stead and assumed gigantic proportions. We meet no less terrible monsters among the mammals of this period than we did among the *Jurassic* reptiles. Our cuts show some of them.²³⁻²⁴ They were at first not very markedly similar to present forms, but they approach these forms visibly in the higher *Tertiary* strata.

Together with the imperfectly developed apes of this period, a being appeared among these primitive forms that may have been the ancestor

THE MAKING OF THE WORLD

of man. Wilhelm Bölsche has treated this point very fully in his "Evolution of Man."

This vigorous forward development of life on our planet was interrupted by the mysterious *Ice Age*, with its repeated changes of temperature. We have referred to its probable causes on preceding pages. Just as the coming of the change of seasons in the beginning of the *Tertiary* period brought about the natural selection of more perfectly adapted forms and thus created the multitudinous race of mammals, so the struggle against tens of thousands of years of variation through seasons and temperature on the edges of the advancing glaciers transformed an animal into a man. No mere adaptation through a change of bodily structure was sufficient in this struggle. Only the growth of an intelligence which knew how to master the hostile elements of nature could accomplish this step.

Thus we arrive at the highest stage of vital development. Man was born. He conquered the earth. His intelligence increased to such a wondrous degree that it could encompass the entire universe. An entirely new direction of creation was thereby inaugurated. We are still moving upon the lowest plane of this new course. We are the protozoans among the intelligent be-

THE MAKING OF THE WORLD

ings that control the forces of nature. We have entered upon the road toward inconceivably glorious aims.

Penck claims that there were at least four long *Ice Ages*, each of which is distinguished by its own variations of temperature. Warmer spells were interpolated between each cold period, and in those mild times the melting glaciers produced a luxuriant growth of grass in wet valleys. For this reason it was especially the herbivorous animals which could develop during those interglacial periods. In the deposits of this *Quaternary* period, which comprises the *Ice Ages*, and in those of the *Diluvium*, which followed the last general glaciation, of which our own period is still a continuation, we encounter those gigantic pachyderms, such as the mammoth, whose remains we find frequently in a frozen state, with the flesh and hair still intact. Even these giants were assaulted by man, and he vanquished them.

We have come to the end of our presentation of the making of the world, which we saw blossoming into its present beauty out of chaotic primitive darkness. We limited our observations during the last half of this work to the earth, because we know only of *its* special phases of development. But wherever we were able to make

THE MAKING OF THE WORLD

any comparisons, we ascertained a general uniformity in the materials which build worlds and in the natural forces acting through them. And the heavens still show us an almost complete uniformity in all great principles of world-development. In view of these facts we cannot doubt that there are millions of globes like ours in the vast structure of the universe, even though we have no information about them. As for the relatives of the earth, the other planets of our solar system, which are the only ones accessible to a closer scrutiny on our part, they differ from our globe only in such a way as children of the same parents in different stages of growth. We need not wonder, therefore, that they do not exhibit any definite traces of such a life as that of our earth. Mars with its canals also leaves us in doubt. But I may speak more clearly on this point in one of the following volumes of this library.

When we look up to the starry firmament with its millions of suns, we may be sure that the eyes of intelligent beings on other globes are scanning our sun, just as we are theirs, looking for kindred intellects. Perhaps the time is not far when our mastery over the forces of nature which extend through the entire universe will be so great

THE MAKING OF THE WORLD

that we can send, not only our glances, but our voices to our brothers on other globes — and get an answer from them. Life has come out of the depths of the universe to us, at least that is the only explanation we have. It spread over this globe from the most minute beginnings. It expanded the horizon of the animal into that of man, who can encompass not only things next to him, but also his whole planet, and who can speed with his thoughts through the universe from which the germs of his life have come. Perhaps he will be able, at some future time, to enter into intellectual communication with more highly organized beings on other world-bodies and to exchange his knowledge for theirs, just as our minds can now enter into communion with other human minds without touching them bodily.

Our intellect, with its power and knowledge, has the universe open to it.

But no matter how highly our world and others in the universe may develop, there will be a time when they must descend. The circulation of universal development must alternate between rise and descent.

The circulation! Is this term correct? If the universal process were swinging indeed back and

THE MAKING OF THE WORLD

forth between such cycles, we might justly ask scornfully or even despairingly why we must forever turn around in a circle, what we are living for, since we and all worlds must always be destroyed. Then all our striving for perfection, all our incessant endeavors, would be in vain. Is it not a blasphemous stultification of the spirit of the universe, who created all this, to think that this resistless impulse toward higher development, which is stirring not in us alone, not merely in all living things, but in every particle of nature, should lead to nothing but destruction? Should this impulse build up ever higher organizations of matter, from a growing atom to systems of Milky Ways and finally produce the desire for good, only to end in chaos? Would not our existence be useless and not worth the pains which we continually endure in the struggle against all imperfections, if the entire universe in which we live had no purpose?

But what can be the purpose of the universe? Is it there for our enjoyment? Or is it there in order that we may share the feeling of the pessimists who derived their despair from such thoughts as these? Should we forever suffer with them? We could think so while we imagined that man and his world were the center

THE MAKING OF THE WORLD

of the universe. But Copernicus, it is said, hurled us back into the Naught. We know now that we are less than infusorian animals which swarm in every drop of sea water by thousands. The world-process cares no more about our sufferings, our despair, our happiness, than we do when we inadvertently kill thousands of minute beings by a step of our foot.

Is not this thought still more terrifying and crushing? We are supposed to be nothing but mere specks of dust in a stupendous and feelingless chaos of wheels speeding eternally through the infinite universe without an aim. Then why have just these specks of dust feelings and an intellect which in spite of its minuteness can grasp the immeasurable, or dream of it? Is it only in order that we might feel the unfathomable chasm which surrounds us on all sides of our solitary cell?

How meanly, how narrowly, think those who ask such questions! They measure large and small, insignificant and worth while, by their own petty standards. Cannot a small body be as valuable, or infinitely more so, than the immense body with its tremendously clumsy effects which often destroy more than they build? We took a peep into the world of atoms and saw that in

THE MAKING OF THE WORLD

invisibly minute dimensions an inscrutable multiplicity of events was working with great force to build incessantly the structure of the universe, while the tangible substance composed of those molecular world-systems lies inert. Heat, light, electricity are born only out of the forces of these minute particles, and with them all chemical effects on which the birth and death of the visible world are conditioned. The wonderful carpet of living nature is woven by these smallest meshes of atomic organization.

We cannot close our mind to the fact that there is a striving for a higher order, for a more complex organization, at least in that portion of the universe and that span of time which we can observe. This striving clearly reveals the aim of our section of the universe. It is the aim to produce out of simple structures the more complex. This supplies us with a standard of measurement for that which is really of value, and not for man alone. From this point of view a single molecule of protein is more valuable than a whole mountain of elementary substances, for instance of limestone. A molecule of lime consists of one atom of calcium, one atom of carbon, and three atoms of oxygen. Protein consists of five elements, namely of the four so-called *organogens*,

THE MAKING OF THE WORLD

to wit, carbon, hydrogen, oxygen, and nitrogen, and of a small percentage of sulphur. But many thousands of these atoms arrange themselves in one protein molecule in a solid and very complicated order which has not been fully analyzed. They swing around a common center and form a world-system compared to which our solar system is very simply organized. An atom of carbon therefore becomes immensely valuable when it has risen in the scale of the world-process from a molecule of limestone to that of protein. A protein molecule is more valuable because nature can accomplish more with it by assigning more complicated tasks to it in the work of higher development. And for this reason the highest duty of the atomic world, at least on earth, must be to form a molecule of protein in the brain of man, so that he may lead the forces of nature by its help and thereby hasten the world-development into a faster pace than it would assume without a guiding intelligence.

For this reason, also, the brain of a single human-being is worth more than whole flocks of suns, even from a higher point of view than a purely human one. In those clusters of suns the elements are crudely arranged. The world-development progresses by first arranging large

THE MAKING OF THE WORLD

bodies out of small ones in a rough way and then working out small details out of the rough, thus making the small ultimately more valuable than the large. So does a sculptor proceed in working out a statue. In this clarified view we human beings are more valuable than anything else on earth. Of course, we must recognize at the same time that we can hold this position only by utilizing the highest organization of matter, which we are, for the further progress of the whole. For the value of each individual organization is measured by its usefulness for higher stages. An egoist who thinks only of himself and his own particular welfare becomes useless or dangerous for the whole, and the community isolates him more and more or expels him. By this necessary reaction against himself the egoist feels that the world surrounding him interferes with his overestimation of himself, and so he hates it more and more and becomes a pessimist. He has as little use for the world as the world has for him, because he has no useful purpose in it.

However, all these considerations do not do away with the fact that all this must come to an end. Even the most complicated protein molecule in the brain of the greatest of all thinkers

THE MAKING OF THE WORLD

must decay some day and dissolve into its primitive components. And all thoughts which have blossomed in the countless æons, and all creations of man and nature, must ultimately sink back into chaos from whence they came. No step forward has ever been made for all eternity, and none are enduringly valuable. Everything must return from whence it came.

And if it were really so, should we complain? Is not this striving for perfection, which is exhibited by all sentient creatures, a source of infinite joy to them, or at least to us? Would we be happier if fortune fell into our lap without any struggle of our own?

These questions are rather out of place here. But we must answer at least one of them. Do all the cycles of the world-process return to the zero point? Does nothing remain of the old creation after the end of some world? Is the balance of the universe really equal to zero?

It is certainly not so in the individual stages of world-growth. According to the views presented in this work the atoms are also destroyed within their own world-systems. But in the disintegration of a radium atom, which represents a climax in the evolution of that atomic world, we observe that it radiates not only electrons, those smallest

THE MAKING OF THE WORLD

of all particles of matter known to us, but also quite a number of other and larger particles. The disintegrating atomic world does not revert completely to its primitive condition. The larger particles, when forming centers of new worlds, will rise more rapidly into higher stages than they would if they had to start from a more primitive condition, like the smaller ones. And the same holds good in the case of large celestial bodies. Their lifetime is likewise limited. In the process of evolution which leads to the union of two shattered world-bodies and the birth of a new one, large lumps of matter lag behind and thereby determine the great outlines of the newly arising system. We also notice the same fact in the intermediate stages. Every dying individual represents the end of a world. But every new generation adds something new to the things inherited from its ancestors, although each generation must start out from the age of childhood. A tree sheds its leaves in the winter but bears still more leaves in the next summer. And it continues this until it declines in old age and falls to pieces. But in the meantime the young trees have grown up in its stead and strive for higher development.

The various organizations in all stages of the

THE MAKING OF THE WORLD

world-process branch out more and more. Primordial atoms become chemical atoms, and although these have a limit of development they can assemble into molecules. When the cold increases, the orbits of the molecules become smaller, the substances contract, and this process may continue so far that the forces available in that stage do not suffice to effect a separation of the molecules into atoms. We might imagine that such processes as these produced the chemical atoms which we cannot divide any more. The molecules then group themselves into systems of a higher order, and we can plainly demonstrate this. A crystal consists of an infinite number of molecules, which, arranged in a wonderful order, form a new body. Analogically we may regard world-bodies as crystals of a higher order, or even as atoms, and the Milky Way as a molecule of the largest order. We have seen that world-bodies also approach one another continually, that the sun-atoms forming a Milky Way grow into larger atoms which become inseparable in a higher stage. Thus worlds grow from one stage into another. Atoms become suns, and suns are but atoms of another stage of development. We cannot find either a beginning or an end in the scale of universal

THE MAKING OF THE WORLD'

evolution. There is nothing to prevent us from assuming that chemical atoms are world-bodies carrying life on their surface like our earth, and that the earth is but a skeleton of a living organism in which human beings play but the role of cells, hastening hither and thither like blood corpuscles and contributing toward the preservation of the whole.

And since we do not observe any limit downward or upward in this regular succession of natural development, we have no means of ascertaining whether there is any limit to the possibilities of higher evolution. There was a time when it was said that the entire universe must come to an end, because the extreme cold of space would ultimately render all world-bodies rigid. This would imply that all the circling motions of atoms, which cause heat and all other chemical and physical phenomena, would cease, so that there would be a perfect equilibration of forces and a complete rest and inactivity. This condition was supposed to last eternally after it had been established. That is to say, the world would be marching toward a death from which there would be no resurrection.

Our point of view does not enable us to share this opinion. Of course, it is certain that the

THE MAKING OF THE WORLD

internal motions of the present atoms in their molecules must cease; whenever they reach the point of absolute zero. But this means simply that the molecules have become atoms of a higher development, and that the universe, instead of falling into eternal death, is starting on a higher cycle. Take it that the matter of the entire solar system had gathered and reached its maximum of density, so that not the smallest particle could move within this cosmic atom, then it would still have its motion through space, just as the primordial atoms had once upon a time. And this cosmic atom would find another cosmic atom at some time, with which it would unite and form a new molecule. In their tremendous collision each cosmic atom would be partially dissolved into primordial atoms. This we have seen taking place in the case of the new star in Perseus.

The world-process can come to an end only if the matter of the universe is something finite, if it is not incorporated in an infinity of worlds which unite into ever new organizations. So far as we can see, search, and think, the universe is infinitely great. Whether it is really infinite we do not know and shall never know. Only an infinite spirit can grasp the infinite.*

* See Joseph Dietzgen's essays on this point.—TRANSLATOR.

THE MAKING OF THE WORLD

So far as our faculty of cognition reaches, then, we cannot conceive of any limits to the infinite upward development of the universe. Let us enjoy our share of work in this eternal uplifting, and be happy in the thought that it can never come to an end.

Not an atom is lost in the universe. Neither is the value of our work in the struggle for perfection ever destroyed. We do not live in vain.



ILLUSTRATIONS

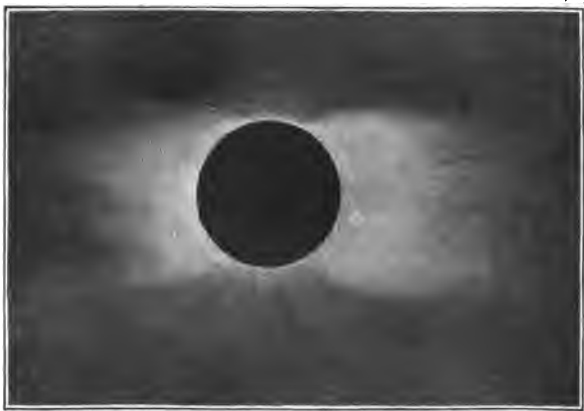


Figure 1. Corona of the Sun during a Total Eclipse.



THE MAKING OF THE WORLD



Figure 2. (See page 13.) The Nebula in Orion, after a drawing made at the Washington, D. C., observatory.

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THE MAKING OF THE WORLD



Figure 3. (See page 15.) Spiral Nebula in Canes Venatici. Photographic plate of Yerkes observatory.

THE MAKING OF THE WORLD



Figure 4. (See page 15.) Nebula in Andromeda. Photographic plate of Yerkes observatory.



THE MAKING OF THE WORLD

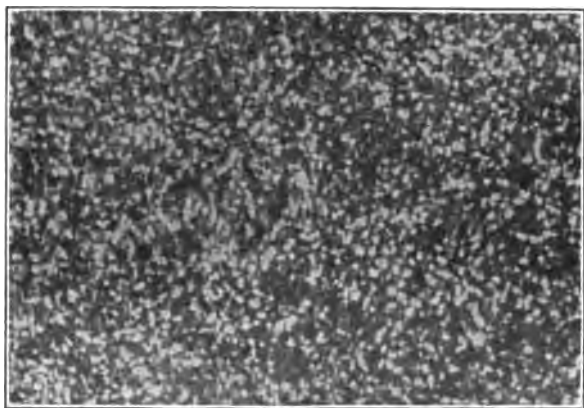


Figure 5. (See page 31.) Granulation of the Sun's Surface. Photographic plate of Meudon (France) observatory.

THE MAKING OF THE WORLD



Figure 6. (See page 33.) Star Cluster in the Centaur.

134

THE MAKING OF THE WORLD



Figure 7. (See page 34.) Milky Way in 6 Anseris.
Photographic plate by Professor Wolf of Heidelberg.

THE MAKING OF THE WORLD



Figure 8. (See page 35. America Nebula. Photographic plate by Professor Wolf of Heidelberg.

THE MAKING OF THE WORLD

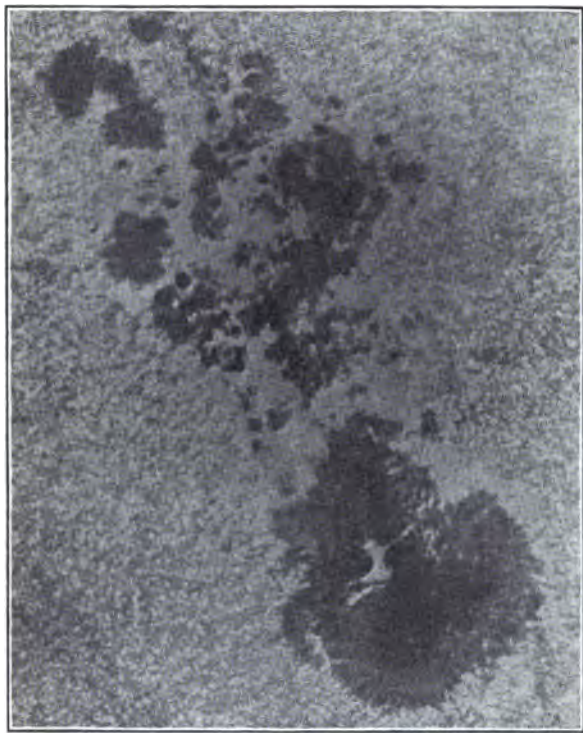


Figure 9. (See page 47.) Sunspots, after the photographic sun atlas of the Meudon observatory.

l o r n

THE MAKING OF THE WORLD



Figure 10. (See page 49.) Protuberances at the circumference of the sun. The sun is eclipsed by the moon.

NOV 11

THE MAKING OF THE WORLD



Figure 11. (See page 69.) Geyser in Yellowstone Park, Rocky Mountains.

THE MAKING OF THE WORLD



Figure 12. (See page 74.) A Crease in the Rocks on
Axen Road, Switzerland.



THE MAKING OF THE WORLD

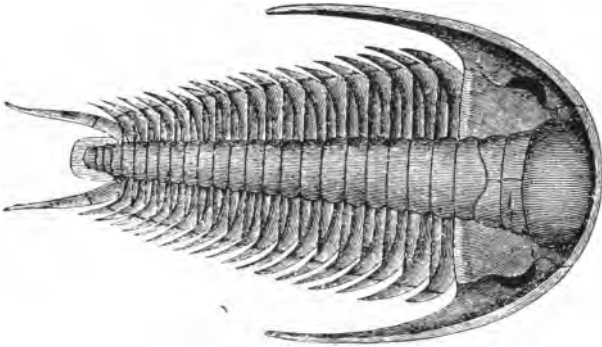


Figure 13. (See page 89.) A Cambrian Trilobite.

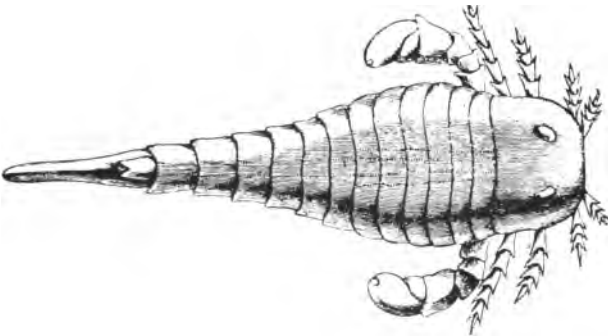
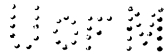


Figure 14. (See page 91.) Silurian Crawfish, after Fraas.



THE MAKING OF THE WORLD



Figure 16. (See page 95.) Landscape from the Carboniferous Period.



THE MAKING OF THE WORLD

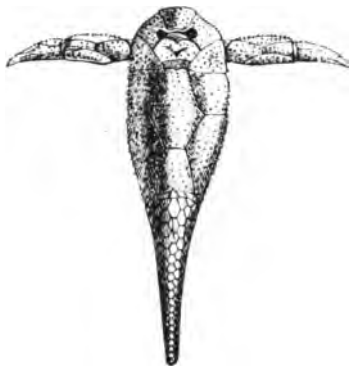


Figure 15. (See page 92.) A Devonian Fish with Armored Shell, after Zittel, Palaeozoology.

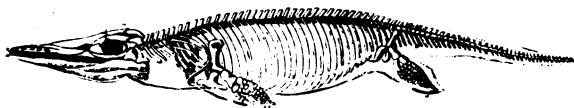


Figure 17. (See page 102.) Ichthyosaurus from the English Lias, after Owen.

THE MAKING OF THE WORLD

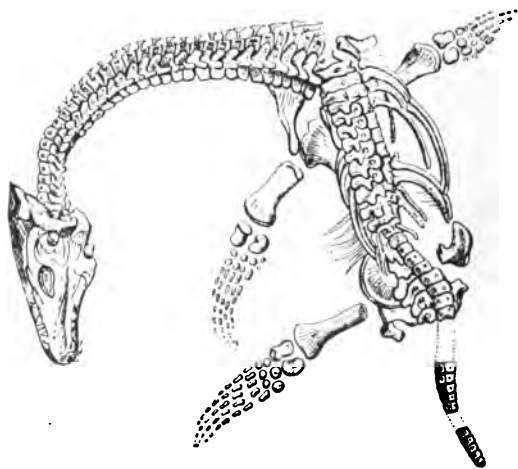


Figure 18. (See page 102.) Skeleton of Plesiosaurus from the English Lias, after Fraas.

THE MAKING OF THE WORLD



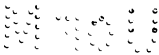
Figure 19. (See page 104.) *Ceratosaurus*, a giant Lizard from the Jura. Restored by Gleeson in the Smithsonian Reports.



THE MAKING OF THE WORLD



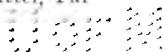
Figure 20. (See page 104.) Pterodactylus from the Solnhofen Slate, after H. von Meyer.



THE MAKING OF THE WORLD



Figure 21. (page 106.)
Archæopteryx from Solu-
hofen, now at the Berlin
Museum, after Zittel, Pal-
æozoology.



THE MAKING OF THE WORLD



Figure 22. (See page 112.) Petrified Leaves, found in Spitzbergen, after a photographic plate by the author.

